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REINFORCED CONCRETE BUILDING WORK FOR THE UNITED SHOE MACHINERY CO., BEVERLY, MASS.

By George P. Carver.*

The increasing use of reinforced concrete in factory building construction is illustrated in a notable manner by the new works of the United Shoe Machinery Co., which are located at Beverly, Mass., about 19 miles from Boston. These works consist of 10 buildings, comprising two machine shops, each 522 × 62 ft.; a storage and shipping house, 280 × 62 ft.; a forge shop, 200 × 62 ft.; a foundry, 222 × 108 ft.; a power-house, 100 × 90 ft.; two service buildings, each 110 × 80 ft., and two smaller buildings, all of which are built entirely of reinforced concrete, with the exceptions of the roofs of the foundry and the forge shop. So far as we know, no manufacturing plant of equal size has hitherto been built of reinforced concrete. In general, the structural details are simple, and such novelties as exist result rather from the magnitude of the work than from any intricacy of design. The following paragraphs cover the essential features of design and construction.

The arrangement of the buildings composing the plant is indicated by the general view Fig. 1, and is shown more exactly by the plan Fig. 2, which also shows the accessory service structures. The character and purpose of the several buildings may be explained briefly as follows: The two main buildings, designated as buildings A and B, will be used as machine shops. They are both four-story structures, consisting of reinforced concrete columns carrying slab and girder floors and roofs and inclosed by curtain walls. These buildings are connected by two four-story structures of the same general type as the main buildings, which accommodate in their basements the heating apparatus for the main buildings A and B, and provide sanitary apartments, shower baths, lockers and tool rooms on their upper floors. Building C is identical in construction with buildings A and B, and, like them, is designed for machine-shop work, but is for the present to be used for storage and shipping purposes. It is connected with building B by a narrow building serving as a passageway, and for tool rooms and fan rooms. Buildings D and E, used as a forge shop and a foundry respectively, are detached structures with steel truss roofs and concrete wall columns and curtain walls. The forge shop is divided longitudinally by a reinforced concrete center partition from floor to roof; on one side of this partition is the hardening plant and on the other side is the drop forge plant. The foundry has a basement for sand storage under one half, a ground floor, and a charging floor. The power-house is entirely of reinforced concrete, a partition dividing it longitudinally, and giving a center support to the roof girders. On one side of the partition is a boiler room, and on the other side an engine room with a basement. The smoke-stack is of reinforced concrete. The equipment of the several buildings needs no further mention than the comment that it is suited to the purpose of the building in each case, and is as complete and perfect as could be devised.

*6 Endicott Building, Beverly, Mass.

GENERAL CONSTRUCTION.—The general construction of the several buildings is illustrated by the drawings of Figs. 3 to 5, inclusive. Fig. 3 shows the construction of the main buildings, designated as buildings A, B and C. As will be seen, each building consists of four longitudinal rows of columns spaced 20 ft. apart c. to c. The columns in each row were also spaced 20 ft. apart. The wall columns are rectangular in form, and are solid on one side of the building and hollow on the other side, the purpose of the hollow columns being to serve as flues for distributing warm air from the heating system. At the ground floor the wall columns are connected by a base wall resting on a spread footing. At the first-story level the columns are connected by a hollow girder, and at the second and third-story levels and at the roof level they are connected by solid wall girders. The 20-ft. panels between wall columns are filled with two windows each, the space being subdivided for this purpose by a solid concrete pier in the first story and by mullions in the stories above. A parapet wall of concrete crowns the cornice girder at roof level. The interior columns are octagonal in section, and are made solid.

The ground floor is a slab of plain concrete resting on the fill. The upper floors and the roof are slab and girder construction. Each transverse row of columns carries a floor girder, and between each pair of girders there is a bridging beam extending across the building from wall to wall. The girders and bridging beams carry floor beams spaced from 3 to 4 ft. apart. The floor slab rests on top of the girders and beams, and is in one piece with them. This description applies to all the floor bays except the three at the ends of the buildings, which are constructed as shown by the plan Fig. 4. Figs. 3 and 4 also show all details of the reinforcement for the floors, columns and girders.

The wall construction of the foundry and forge shop is the same as for the main buildings, but their roofs consist of steel trusses carrying timber and slate roofing. Like the main buildings, the power-house is of reinforced concrete throughout. Its construction is of interest chiefly for the long-span roof girders, and the column construction for bridge crane tracks. These details are clearly shown by the drawings of Fig. 5.

EXPANSION JOINTS.—To provide for expansion and contraction, and for shrinkage in the long stretches of side walls and floors, expansion joints or shrinkage joints were introduced at intervals. These joints were, with one exception, simply planes of weakness extending transversely through the building. These joints are located, one joint 50 ft. from each end of the building, and a joint every 60 ft. between the two end joints. The joint in each case passes through the center of a bridging beam, and is a joint only in the sense of being a plane of weakness constituted by building one-half of the beam and letting it set, and then building the other half against this hardened face without any effort to bond the new work to the older. At the center of the building, however, an open joint 2 ins. wide was formed across the structure from roof to foundation. Details of this joint are shown by Fig. 6.

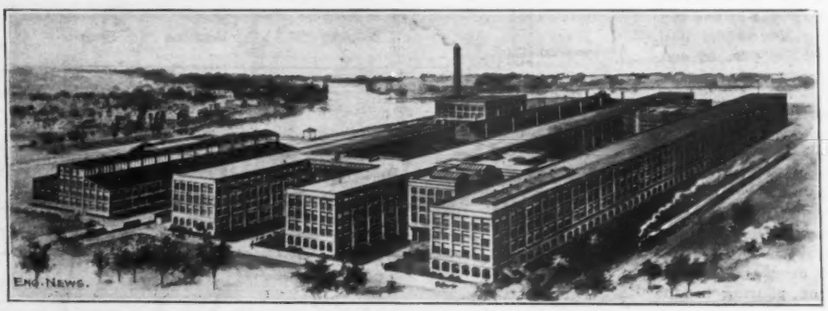


FIG. 1. GENERAL VIEW OF THE UNITED SHOE MACHINERY WORKS AT BEVERLY, MASS.

HEATING SYSTEM.—Mention has been made above of the hollow columns for distributing warm air to the main buildings. Fig. 7 is a general plan of the heating system. In the basements of the connecting wings, A B S and A B N, is installed the heating apparatus, consisting of large fans, engines to run same, and sets of wrought-iron pipe coils. This apparatus in working order draws the cold air down through an open shaft leading to the roof, through the pipe coils, which are fed with steam from the power-house. The air when heated is forced through an opening in the wall of the basement into concrete ducts varying in size from about 6 ft. square at this end to about 2 ft. square at the smallest section. These ducts are led along outside the buildings 3½ ft. below the surface of the ground, and 10 ft. from the wall. At intervals of 20 ft. (the distance between the wall columns) there are openings in the sides of the duct fitted with dampers, which deflect the hot air into branch ducts feeding the flues in the wall columns. The hot air is thrown into each story through an opening in the columns, which is fitted with a deflector. These ducts run along the west side

of building A and the east side of building B, being fed with hot air by the fans in the basements of A B S and A B N. They also are run along the east side of building C to heat that building, and are fed by the fans in the basement of building B C.

CONSTRUCTION WORK.—The first work on the part of the contractors was to erect a pair of traveling towers running on tracks parallel with each other, situated at some distance from the north and south ends of the buildings and spanning them by means of a suspended cableway

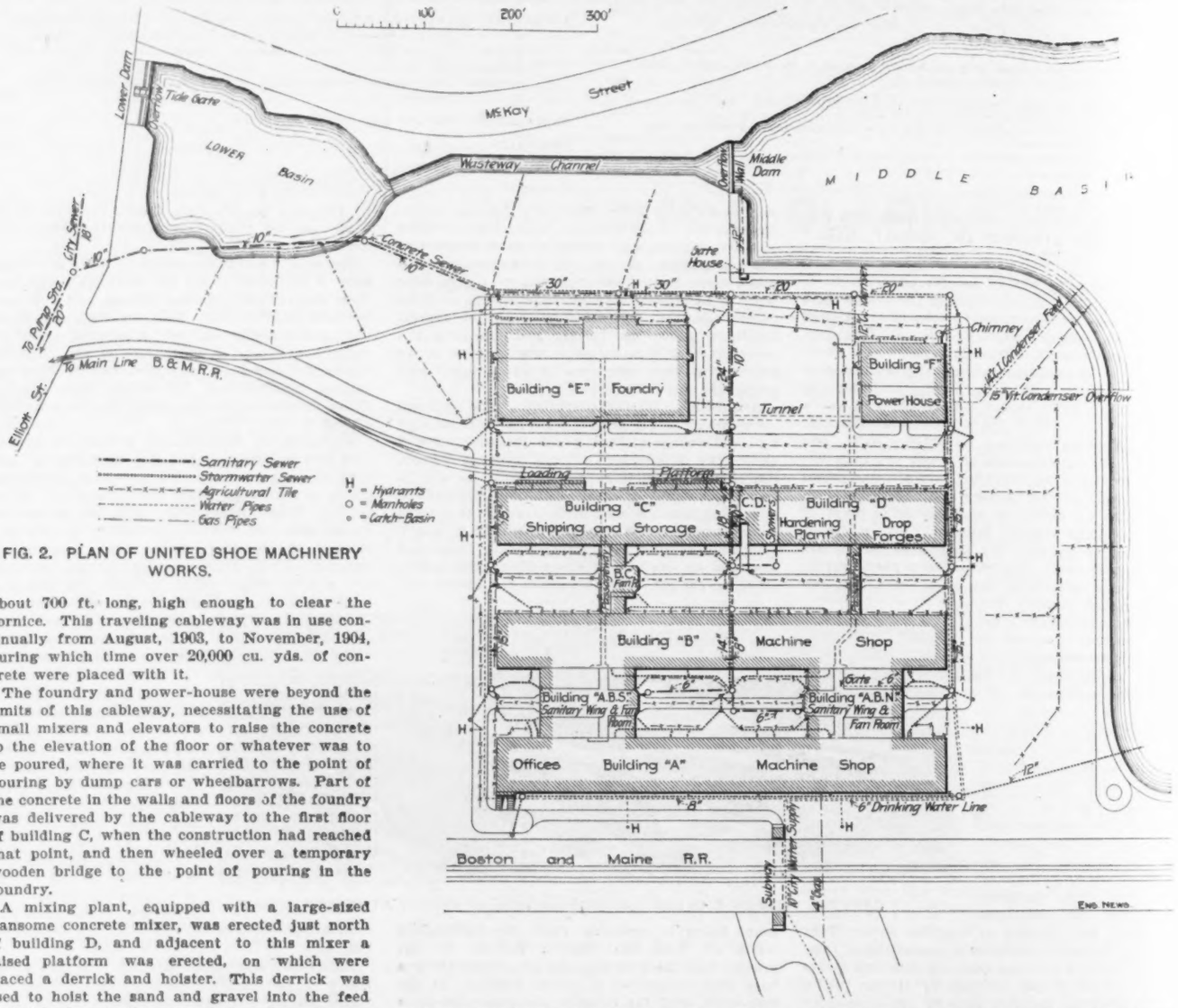


FIG. 2. PLAN OF UNITED SHOE MACHINERY WORKS.

about 700 ft. long, high enough to clear the cornice. This traveling cableway was in use continually from August, 1903, to November, 1904, during which time over 20,000 cu. yds. of concrete were placed with it.

The foundry and power-house were beyond the limits of this cableway, necessitating the use of small mixers and elevators to raise the concrete to the elevation of the floor or whatever was to be poured, where it was carried to the point of pouring by dump cars or wheelbarrows. Part of the concrete in the walls and floors of the foundry was delivered by the cableway to the first floor of building C, when the construction had reached that point, and then wheeled over a temporary wooden bridge to the point of pouring in the foundry.

A mixing plant, equipped with a large-sized Ransome concrete mixer, was erected just north of building D, and adjacent to this mixer a raised platform was erected, on which were placed a derrick and hoister. This derrick was used to hoist the sand and gravel into the feed pocket leading to the gage of the mixer. It also hoisted cement to the level of its platform, which was the same as the platform around the gage.

On the area now occupied by building D were stored enormous piles of sand and gravel, which were used as needed, and cars of fresh material were constantly brought in on the spur track, which ran close to the mixer, to replenish the store piles. A narrow gage track was laid from the mixer along the north end of the buildings, which was used to convey buckets of concrete from the mixer to a point directly under the cableway, where each was picked up and hoisted high enough to clear the work and run to a point where the concrete was to be used, and lowered directly on to the floor forms or on to a mixing board, the catch chain unhooked, and the bucket slowly raised, allowing the concrete to run from the bucket, which, when empty, was taken up and sent back to the mixer to be refilled. The car was long enough to hold two buckets, so that it could take over a full bucket and exchange for an empty one. The track was located directly under the discharge scoop of the mixer, so that the buckets were loaded while on the car. A great amount of work was done at night, so that the concrete would practically all be poured before cold weather.

The greater part of the concrete in the footings and foundation walls was mixed by hand at the location of the footings and walls. The lower course of footings was placed and allowed to set, when the form for the next course was set, braced and filled with concrete. This course being set, the top course form was set and poured. A ½-in. twisted rod was set up vertically protruding from the top of the upper course about 9 ins. This rod was eventually embedded in the lower part of the columns. In some cases, as at the south end of building C, where the ground was soft, some of the footings and walls were carried down 9 or 10 ft. to rock. The lower course of the larger footings and the hot-air flue columns were reinforced with twisted steel rods.

The footings and walls below grade of buildings A, B and C were practically all poured before any of the work above grade was commenced. On the completion of the footings and foundation walls of a building, the clay subgrade of the floor was leveled and well tamped, and a 4-in. layer of concrete, forming the subfloor was laid and rolled, and leveled to the height of the tops of the footings at elevation 14.

When the subfloor had set, the spiral coil and rod reinforcement for the lower interior columns were set up and enclosed in a column form set to line and temporarily braced. These lower columns were 22 ins. across and octagonal in shape. The exterior columns on the west side of building A and east side of buildings B and C were contructed to act as hot-air flues. Before the forms were set for these columns, a hollow brick lining was built up to the grade of the next floor, the brick lining was then mopped with asphalt. This lining was then enclosed in a rectangular wooden form allowing for an 8 to 12-in. thickness of concrete entirely around the brick. The columns were reinforced with vertical rods and hoops placed at intervals in the height of the column. A form was set on the interior face of these columns between the brick lining and the form, to allow for an opening for the hot air to pass into the building. These openings were placed about 9 ft. from the floor. The column forms were made up of sides of 1¼-in. stock on which were secured made-up collars spaced about 30 ins. apart. The sides were held together by long bolts fitted with washers run through the ends of this collar piece which protruded 6 or 8 ins. from the side, and which was slotted to allow the rod to be set and taken off easily. The column forms, like the other forms, were used over and over again, repairs being made at various times as were necessary.

When all the column forms had been set and temporarily braced, the forms for the girders were set up, resting on tall horses spaced about 3 ft. c. to c., the ends of the girder forms fitting with the top of the column forms, Figs. 8 and 9. These girder forms consisted of a bottom board set on the horses, and sides made up of short pieces,

leaving T-shaped openings for the beam forms, which were set in a manner similar to the girder forms.

The girder forms extended entirely across the building on each row of columns, which were 20 ft. apart. midway between these girders was placed a bridging beam form entirely across the floor. Set between this girder and bridging beam form, running across the building, were set the floor beam forms about 10 ft. long spaced between 3 and 4 ft. apart. On top and between the exterior columns, forms for the lintels over the windows were set, and the sides run up high enough to take in the curtain walls below the windows. On the inside of the forms an opening was left to allow the bonding of the floor with the walls. These low curtain wall forms were braced by a diagonally braced clamp of 2-in. × 3-in. stock.

At a distance of 50 ft. from each end of the building, and at each 60 ft. between for the length of the building, the bridging beam forms were of double width, to allow for the placing of expansion joints. The four corner bays of each floor and the roof were of flat floor construction, no beams being used. This floor was 8 ins. in thickness, and, naturally, the forms were built 5 ins. lower than the forms for the 3-in. floor strengthened by beams. The form for the flat floor was constructed as a level floor laid between the girder forms and the curtain wall for M S. The floor was leveled up perfectly and thoroughly braced and supported by uprights from the floor below.

In the bottoms of the beams and girder forms where the sides and bottom meet, a triangular-shaped wood fillet was placed to give the concrete beam a beveled edge rather than a square edge, which could be easily chipped. After all the girder and beam forms had been leveled and lined up, and securely held in place and well supported, wooden panels, with four strips of 5-in. × 1-in. screwed to the back for braces, were set in the opening between the girder and beam forms on strips secured to the sides of these forms, at the right height to cause the panel to set level and at the proper grade. On top of the sides of the girder and beam forms quarter round pieces of 1¾-in. radius were placed and nailed, the top of the panel being flush with the top of the quarter round strip. Pieces of this quarter round stock were also used where the sides of the beam forms met, and on top of the column forms where they came up to the floor and joined with the panel. The sides of the beam and girder forms were temporarily held apart by strips of the required length. These were taken out as the concrete was being poured.

When the floor forms and column forms were all set and secured to line and grade, the columns were poured up to the level of the bottom of the girder and allowed to set. These columns were poured in the following manner: A mixing board was placed in close proximity to the column to be poured, and upon this board the bucket of concrete from the cableway was dumped. This concrete was usually very wet and of a 1-2-4 mixture of small crushed stone or gravel. Previous to pouring a column, the form was cleaned of all small blocks of wood, shavings or sweepings which had gotten into it. A stream of water from a ¾-in. hose was then turned into the column form. The first 1 or 2 ins. of material put into the column form consisted of a mixture of 1-1½ grout, to make a good bond between the old concrete and the new. On top of this grout was shoveled the concrete from the mixing board, where it had been dumped by the bucket, and men with 14-foot cutting tools made of wood and pointed with metal worked the concrete in between the coil reinforcement and the form, while a man with a heavy tamp compacted the concrete inside of the coil. In this manner good results were obtained and very few voids showed in the concrete when the forms were removed.

After the columns had been poured and had set, and previous to setting the steel rods for the

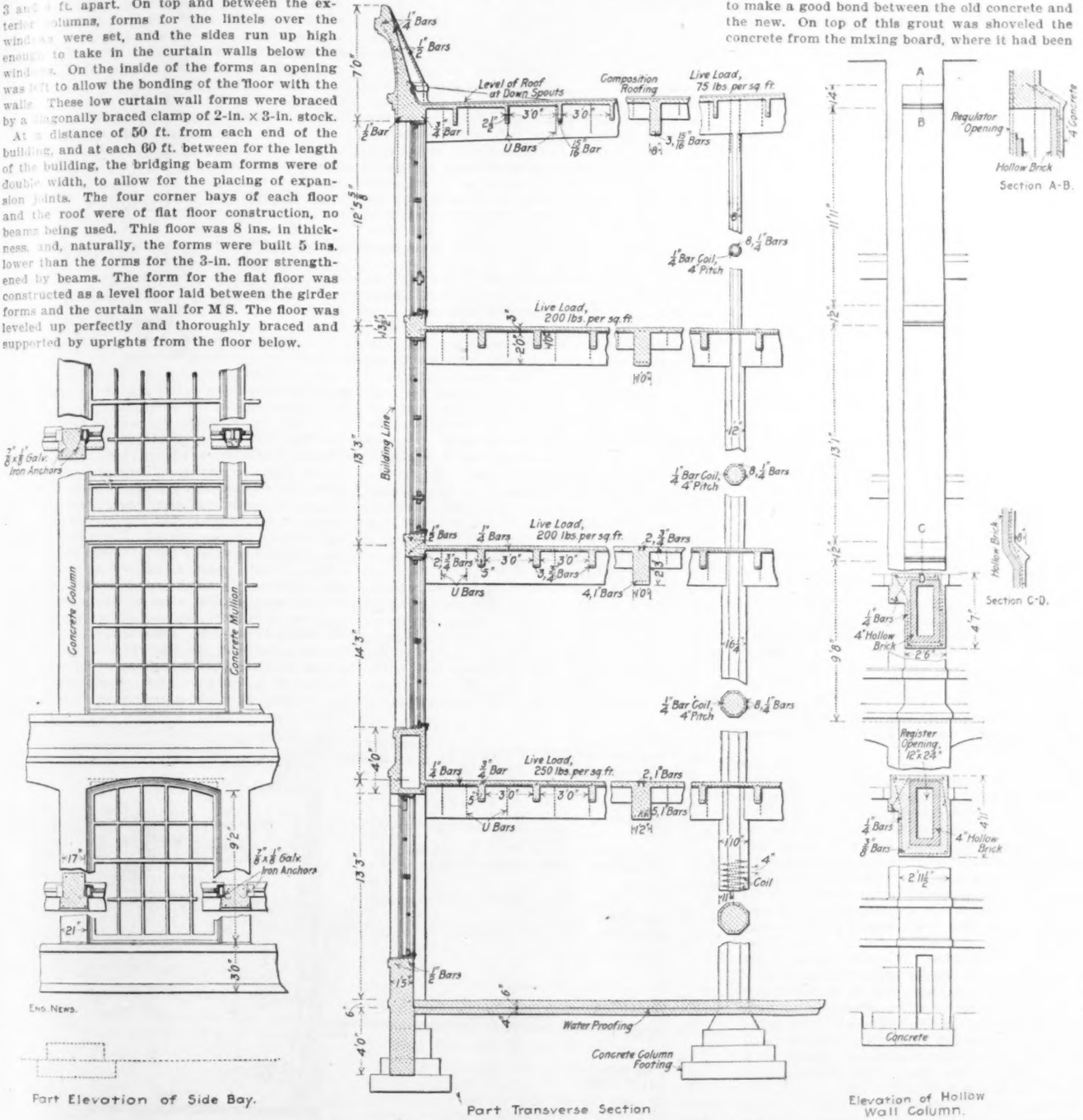


FIG. 3. TYPICAL STRUCTURAL DETAILS OF MACHINE SHOP.

beams, girders and floor, lines were run at regular intervals the length of the floor. In the bottoms of the girder forms and on a beveled wood strip 1½ ins. high, to form a slot in the bottom of the girder, holes were bored ¾-in. in diameter, over which were set small castings holding ¾-in. anchor bolts, which protruded down from the form the required distance in order to be used later as a means for supporting the shafting hangers. A

Arrangement of Reinforcing Bars.

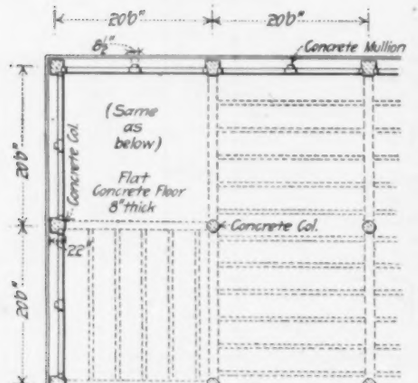


Fig. 4. Part Plan of Machine Shop Showing Corner Bay Construction.

detailed description of this "slot system" for shafting support will be found in Engineering News for March 3, 1904.

All surfaces coming in contact with the concrete were oiled to enable the forms to be removed readily. After the system of anchor bolts had been installed, the forms were treated with a coating of crude oil, and the steel placed in the bottom of the beams and girders. A small supporting template of concrete was made the width and shape of the beam 1½ ins. thick, and grooved on top in as many places as there were rods for the form. These blocks are used to hold the steel in position and keep it the correct distance away from the sides and bottom of the form. They were left in the forms. The rods placed in the bottoms of the beam and girder forms vary in size from ¼ to 1 in., according to the depth and width of the girder or beam. These bottom rods are of a sufficient length to have a bearing on the columns at either end where they are lapped and fitted with a coil coupling, which consists of a coiled spring of flat band steel loosely placed around the lapped ends of the rods.

In connection with these bottom rods are placed U-shaped bars, the lower part of which are under the tension rods. These U-bars for the most part were ¼-in. twisted steel rods, and were usually four in number at each end of a beam to strengthen the beam for vertical shearing strain. They are placed at increasing distances from the column towards the center of the beam, as 8, 12, 16 and 20 ins., these distances depending upon the depth of the beam. The U-bars were secured to the tension rods with wire, and were held in place by a line of wire running between the tops of same.

In the inspection of the work great care was taken to see that the steel was clean and free from rust scales. A thin coat of rust was thought to do no harm, and probably 90% of the steel placed in the forms had a thin coat of rust, but if the steel was coated with rust scales it was not allowed to be placed, but was treated in a pickling bath of sulphuric acid and water, which effectually removed all the rust. In some instances the loose rust was removed by the use of a wire brush.

When the tension members and the U-bars were in place, concreting was commenced. Usually a gang of 25 to 30 men handled the concrete, which was brought in skips by the cableway. Sections 60 ft. long were poured at one time, this distance being the distance between two expansion joints, there being seven 60-ft. sections and two 50-ft. sections, one at each end of the building. When pouring on the south end of building A, the buckets were carried through the air a distance of about 850 ft., and by using two skips a batch was received every six or seven minutes. In commencing the pouring, one or two buckets of "fine stuff," a 1-1½ mixture of grout, were first used to fill in around the steel in the bottoms of the forms. This grout was well worked up and cut with tools so that every part of the steel rod would come in contact with the concrete. After this fine stuff had been spread over an area in the beams the skips would bring along concrete of a 1-2-4 fine gravel or crushed stone mixture, and dump it on the mixing boards, from which the concrete was shoveled into the beams and girders on top of the steel, the concrete being cut continually with a tool shaped like a hoe, with the blade turned down in line with the handle. In this manner the concrete was brought up to the top of the beam, when cantilever bars were placed. These rods were laid along the beam, the centers of the rods being on the tops of the columns and the ends butting. After placing these cantilever rods and embedding them in the concrete, the beams and girders being brought to this height, a layer of concrete varying in thickness from ½ to ¾-in. was spread over the floor area and on this layer were laid ¼-in. rods spaced 1 in. on centers, and running across the floor. The ends of these rods lapped 9 ins., usually over a beam. On top of these rods was laid a layer of concrete of sufficient depth to bring this floor up to within 1 in. of the finished grade. This layer was well rolled with a metal sheathed roller about 30 ins. in diameter and weighing 250 lbs. The wearing surface was laid on this base within an hour or two after the floor had been poured.

The concrete was usually quite wet and usually appeared thoroughly mixed. The wearing surface was screeded to a level surface and then troweled until a smooth finished surface was obtained. After this surface had begun to harden, a line was drawn in same between the centers of the columns. In hot or rainy weather this floor was protected by a canvas covering spread over a temporary framework over the section being finished. After this wearing surface had set, it was spread over with a layer of wet sand, the sand being kept wet continually for a period of ten days or more. The mullions between the window frames and the concrete stair steps were cast separately and placed after the main concrete work of the buildings was done.

Several inspectors were employed and kept notes during the period of inspection, making a record of the condition of the section of floor to be poured, noting the condition of the steel in the forms, seeing that the forms were free from debris and that the steel was free from loose or scaly rust, and the correct number and sizes of steel rods were used. Also that the forms were properly braced, clean and well oiled.

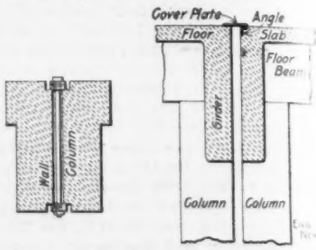


Fig. 6. Expansion Joint at Center of Main Buildings.

A record was made of the time the work of pouring started and ended, and of the location of the section of floor. If at night a note was made as to whether or not the floor was properly lighted up. The time of the arrival of each bucket of concrete was taken, so that the time it had been in transit might be known. A man inspected at the mixer, seeing that the aggregates were mixed in the proper proportions, and noted from which cars cement had been used. The cement was all tested for tension, etc., on the site of the work by a man engaged especially for that purpose.

Two or more test 6-in. cubes were taken from each section while being poured, a record made of the cube number, date, time, by whom taken, proportions of mixture, and conditions surrounding the taking of the cube. After having set the mold was removed and the cube allowed to set for a period of either 7 or 28 days, when the cube was crushed in a hydraulic press registering the result in tons of crushing resistance.

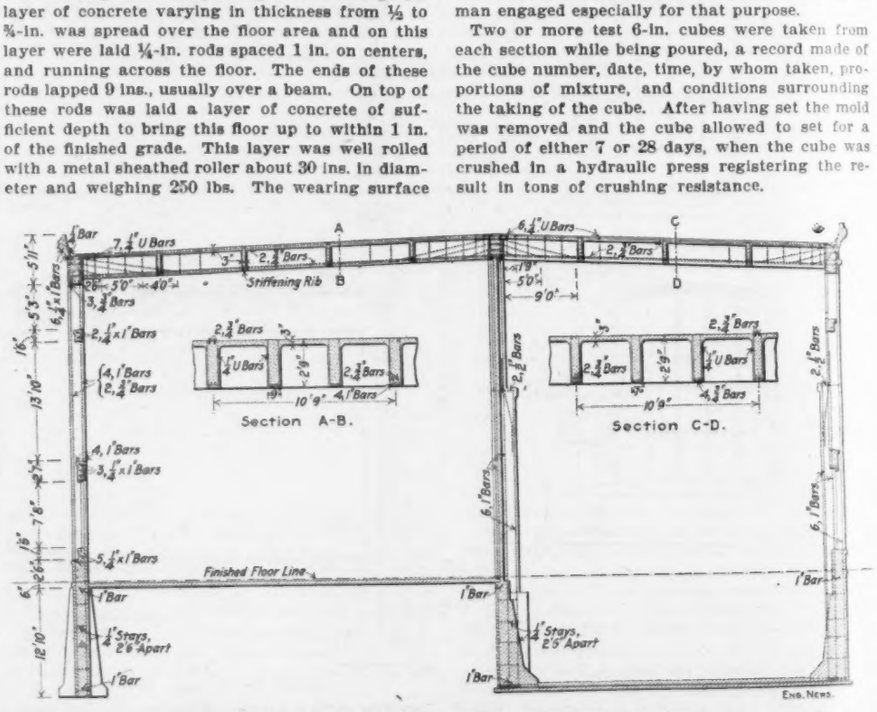


FIG. 5. STRUCTURAL DETAILS OF POWER HOUSE.

On Jan. 1, 1904, all the concrete foundations and footings had been completed. The first floor and supporting columns of building A had been poured, and the second floor forms had been built. The subfloor of building B had been laid and the brick lining for the hot-air flues had been erected. At this stage of the construction, all the work was stopped for the winter, and the concrete work of building A was enclosed in a canvas shield to

protect the work from the cold and the second floor forms from snow. Coke fires in salamanders were kept burning on the ground floor, and the heat arising from these fires caused the first floor to expand some 2⅛ ins. in its entire length of 522 ft. This led to the construction of expansion joints in the center of the building. This expansion joint consisted of an opening 2 ins. wide

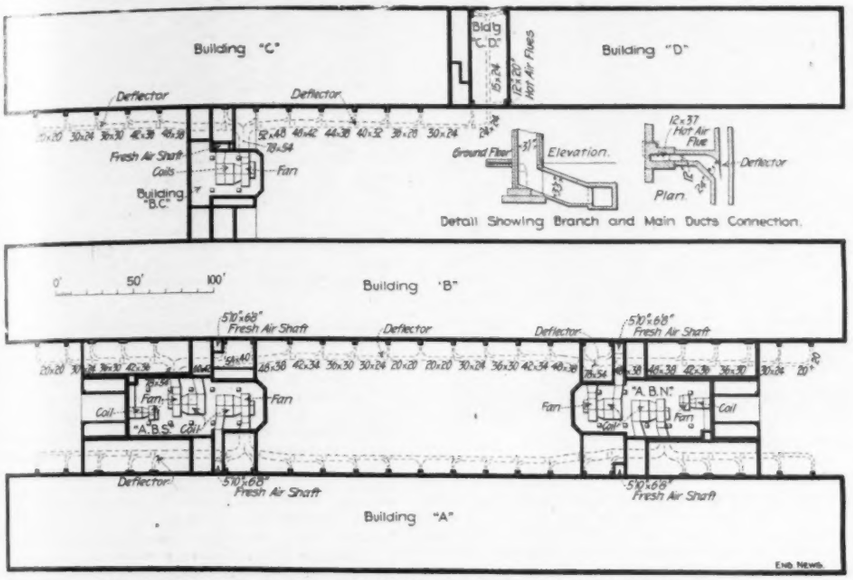


FIG. 7. GENERAL PLAN OF HEATING SYSTEM FOR MAIN BUILDINGS.

carried completely through the building from ground floor to roof, cutting the floors, curtain walls and roof, and causing an octagonal-shaped column to be removed and two rectangular-shaped columns substituted, with the 2-in. opening between them. This expansion joint virtually cuts the building in two. The openings in the floors and walls are covered by strips of galvanized iron, while the opening in the roof is covered with a reinforced concrete protection. Building B also has these expansion joints.

It was noticed that the extreme north end of the first floor has in some manner raised up, and upon investigating the cause, it was found by excavating down around the north wall of the building that the frost had worked in between two separate layers of the wall about 2 ft. down from the surface, and by expanding had raised the entire end of the building over 2 ins. This seam in the foundation was, in all probability, where a day's work

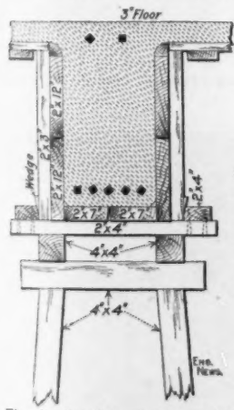


Fig. 8. Section of Form for Girders.

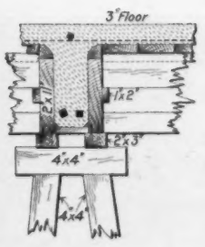


Fig. 9. Section of Form for Beams.

had ended and the top of the old work had not been thoroughly cleaned, and had left a fine layer of clay between the two days' work.

This condition was found to prevail not only the whole length of the north wall, but ran back 40 ft. or more on both the east and west walls. The damage caused by the horizontal expansion joint was remedied by jacking up the end of the building, excavating entirely around on both sides of the wall below the joint, cleaning out same, cutting away some of the concrete, and slowly lowering the end of the building down to grade, care being taken to make a good clean joint. A great deal of the 4-in. subfloor which had been laid in the building was heaved by the frost, causing same to be removed and replaced.

In building B the backfilling had been done on the inside of the walls and the subfloor had been laid. The backfilling outside of the walls had not been done. The frost went through the subfloor into the clay and heaved it, forcing the concrete to the subfloor up and the side walls out, causing the brick flue linings to lean. The flue linings were taken down and the top 18 ins. of the foundation walls were removed and replaced with new concrete. By means of excavating a trench outside of the foundation walls and filling same with coarse screened gravel, as shown by Fig. 10, it is hoped to avoid further damage by the frost.

The accompanying views of the construction show several of the features that have been mentioned. Fig. 11 is a view looking down on the second floor beam and girder forms for building A. Fig. 12 is a view showing the column and girder forms to larger scale. An interior view of one of the completed buildings is shown by Fig. 13, and Fig. 14 shows the exterior of the same building. Mr. Frank M. Andrews, of Dayton, Ohio, was the architect for the buildings, and was represented on the work by Mr. D. J. Andrew. Mr. Ernest L. Ransome, of N. Y., was Consulting Engineer, and the writer, Mr. Geo. P. Carver, Resident Engineer for the United Shoe Machinery Co. R. L. Fosburgh & Sons, of Boston, now incorporated as the Fosburgh Co., were the Contractors. Mr. M. B. Kaven is the General Superintendent of the new plant.

REPORT ON THE POLLUTION OF LAKE CHAMPLAIN THE BOQUET AND AU SABLE RIVERS BY WOOD PULP MILL REFUSE AND BY ALGAE.

Vigorous protests against the pollution of Lake Champlain and two of its tributaries by refuse from pulp mills on the Boquet and Au Sable Rivers led Dr. Daniel Lewis, New York State Commissioner of Health, to instruct Prof. Olin H. Landreth, of Union College, Consulting Engineer to the State Department of Health, to make an investigation and report on the alleged nuisances. Professor Landreth's report, although dated May 30, 1904, was not made public until late in December following. Through the courtesy of Messrs. Landreth and Lewis we are enabled to present an abstract of the report and also of a supplementary report by Mr. G. C. Whipple, Assoc. M. Am. Soc. C. E.

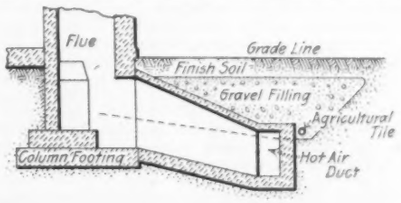
Professor Landreth concluded that the pulp mills did seriously pollute the rivers and the lake, and that besides the direct pollution the refuse from the Au Sable mills contributed to the growth of aquatic organisms and consequent objectionable odors along the lake shore; that the pollution of the Au Sable River had virtually ruined the water supply of Keesville; that sewage pollution from municipalities on the rivers and Lake Champlain also aid in the development of aquatic growths in the lake, although to a less extent than the Au Sable pulp mill refuse, and that this sewage "presents an element of danger to the potability of the water of the lake;" that it would be feasible for the owners of the mills to prevent the pollution therefrom and that they ought to be required to do so under authority conferred by the Public Health Law of the State; and that the department also ought to exercise its powers for the prevention of the pollution of Lake Champlain and Lake George by sewage.

The reports of Messrs. Landreth and Whipple established the very interesting fact that certain unsightly and sometimes offensively odorous deposits along the lake shore were not, as had been popularly supposed, wood pulp, but that they were decaying aquatic growths, mostly falling in the broad class of green algae.

THE BOQUET RIVER AND THE WILLSBORO SODA-ASH PULP MILL.

The Boquet River flows northeast about 35 miles and enters Lake Champlain about two miles southeast of the village of Willsboro. It has a drainage area of 275 sq. miles of rough, hilly country, largely in forest and brush, with a population of 4,500 to 5,000 upon it. The largest village on the river is Elizabethtown, which has a few private sewers leading to the river, and is about 25 miles from the mouth of the river. Aside from the relatively few sewers and privies and a few sawmills, no pollution reaches the river above Willsboro, and such pollution as occurs is insignificant, except that it would affect the character of the river as a source of water supply.

At Willsboro village is located the New York & Pennsylvania Co.'s* works, which produce a fine grade of wood pulp, called "Chemical Fiber." For this the soda-ash process is used, which employs a hot solution of caustic soda to dissolve the gums and resins of the wood from the insoluble fiber or pulp. To recover the soda from the spent solution and from the water used in washing the pulp, use is made of evaporation, drying and burning to get rid of the water and the organic matter. The residue is black ash or charcoal, from which the soda ash is finally dissolved out.



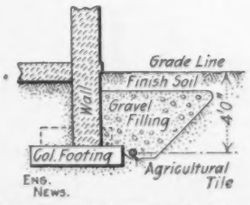


Fig. 10. Wall Footing to Prevent Heaving by Frost.

About 1,000 cords of wood, mostly poplar, bass, beech and white birch, are made into pulp each month.

What is known commercially as "light 58% soda ash" is causticated with lime before being used, as follows: Fresh, unslacked lime is thrown into tanks containing recovered soda-ash solution

*Incorporated in Pennsylvania in 1890. Gen. Mgr., A. G. Paine, Jr., 41 Park Row, New York City; Supt., R. L. P. Mason, Willsboro, N. Y.

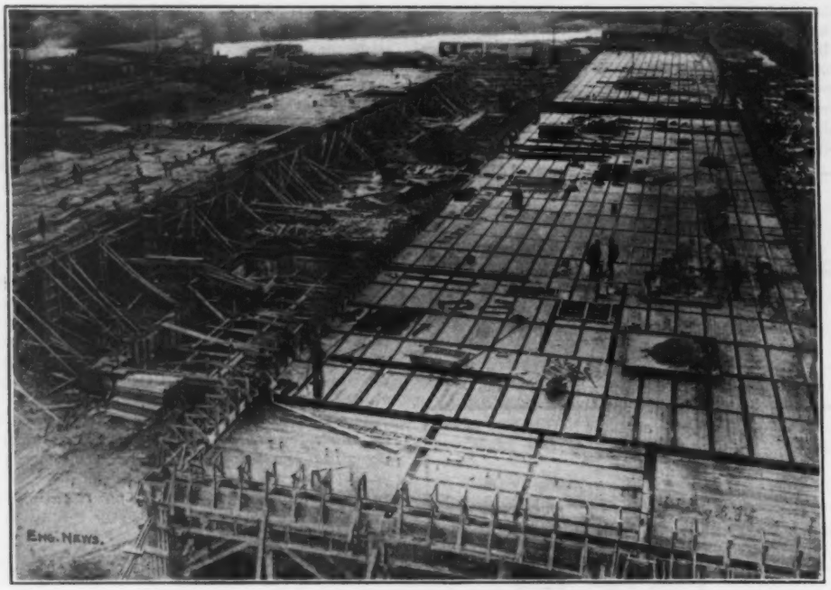


FIG. 11. VIEW OF FORMS FOR SECOND FLOOR OF MAIN BUILDING.

and new soda-ash to make good losses in recovering. The lime slacks and dissolves, and reacting with the soda-ash forms a carbonate of lime precipitate, leaving caustic soda in solution. The reaction is as follows:

$$Na_2CO_3 + CaO\,(H_2O) = 2\,NaOH + CaCO_3.$$

A combination of 106 lbs. of soda-ash, 56 lbs. of pure unslacked lime and 18 lbs. of water produces 80 lbs. of caustic soda and 100 lbs. of carbonate of lime. The lime used at Willsboro is said to be 98% pure, so every 100 lbs. of lime used should produce 175 lbs. of carbonate of lime. Continuing Professor Landreth's report says:

This carbonate of lime, called at the mills "lime sludge," is a refuse product at Willsboro and is run off into the sludge reservoir or basin, hereafter described. The Superintendent reports that about 15,000 lbs. of unslacked lime are used per day, so that about 26,250 lbs. of lime sludge are produced and discharged into the sludge basin per day. If the ingredients are mixed in the above proportions, the lime will all be converted and no soda-ash will remain. If, however, a surplus of lime is used, then the sludge will carry out some lime, and, correspondingly, if a surplus of soda-ash is used, the sludge will carry some uncausticised soda-ash. As each defect represents a commercial loss, it is unlikely that very large amounts of either free lime or soda-ash are allowed to escape, though, as the soda-ash is much the more expensive, some slight excess of lime is probably used to prevent loss of uncausticised soda-ash. Similar determinations of the amount of lime sludge discharged by volumetric data show the amount to be even greater than the above determination.

The next item of refuse discharged from these mills is the "bleach sludge," or refuse from the tanks where the chlorinated lime is dissolved in the preparation of the "bleach liquor" used in whitening the wood fiber. About 5,000 lbs. of chlorinated lime are used per day, and the sludge from the mixing tanks, composed of slacked lime, carbonate of lime and other insoluble materials, amounts to about 3,000 lbs., dry weight, per day. This material is also discharged into the same sludge basin as the lime sludge. The data secured on the *volume* of this bleach sludge indicate even larger amounts than the above determination by weight.

The black ash from the soda-recovery plant furnishes, after the contained soda-ash has been dissolved out, the next class of refuse from these mills. The total dissolved matters from the wood are carefully removed, in conjunction with the soda used as a solvent, by washing the pulp or fiber in tanks with clean water by a systematic method of "concentration" till all remaining traces of soda and all the soluble portions of the wood are removed from the fiber. The water used for this purpose is not wasted, but evaporated by "triple-effect" Yaryan evaporators down to a density of 36 to 39° Baumé, in which condition it resembles coal tar in consistency and color.

This concentrated material, or "stick," as it is called, carries per day about 65,000 lbs. of dissolved woody matter, and about 40,000 lbs. of soda-ash, both free and in combination with the soluble materials from the wood. This stick is then run into a rotary furnace, where the remaining water is driven off, the soda compounds broken up, and the volatile organic matters driven off and burned, leaving practically all of the original soda and the greater part of the fixed carbon in the form of charcoal. From this charcoal or black ash the soda-ash is then dissolved, and the remaining black-ash waste is discharged into the sludge basin used for the other classes of refuse material. It is difficult to ascertain the amount of this black-ash refuse sent to the sludge basin per day, but an approximate method of estimation indicates that it [illegible] not less than 15,000 lbs., and may be much more [illegible] lbs. In form this waste is a light-weight charcoal, occurring in coarse form when it first leaves the furnace, but easily broken up into smaller form and occurring [illegible] in this form as seen along the shores of the lake. The [illegible] of the insoluble waste materials discharged from the [illegible] is the wood waste produced in preparing the wood for the digesters. This material has in the past been largely discharged directly into the river, but during the last year it has been otherwise disposed of. It has been said that the boiler cinders also have been discharged into the river, but my examination indicates that while there is a large amount of this material in the river below the mills, and to lesser extent along the lake shore, it is possible to account for this by the explanation given by the Superintendent that it comes from the washing away of an extensive piece of cinder bank or filling below the [illegible].

Besides the above insoluble waste materials from these mills, there is some soda-ash waste which enters the river. The total amount of fresh soda-ash used per day to replenish losses is between 2,500 and 3,000 lbs. These losses occur principally in the rotary furnace and in the incomplete leaching of the black-ash. The amount of the latter which measures the amount going out into the stream is probably not under 1,000 lbs. per day.

SLUDGE BASIN.

The lime sludge from the causticising tanks, the bleach sludge from the chloride of lime tanks, and the black-ash waste from the leaching tank are, in the normal condition of operation at the mills, discharged into the sludge basin or reservoir which is situated on the opposite side of the river from the mills and further down the river. The waste materials are run across the river through an iron trough suspended from a suspension cable. Owing to a faulty design of this suspension cable and its hangers supporting the trough, the trough sags at the center when materials are running through it, and waste over the side directly into the river. A larger trough has recently been installed with the apparent intention of remedying the defect, but the defect is more a matter of gradient than size, and the trouble continues, though to somewhat less extent than before the change of size.

This trough empties directly into the artificial reservoir or basin which was formed in an old abandoned channel of the river or "cut-off" across a bend through which old channel the river flowed—prior to the construction of the basin—at high-water periods. The basin was formed by building a wooden crib dam across the channel at both upper and lower ends of the old channel, where it leaves and rejoins the main river channel, thus enclosing an area of some eight or ten acres, which if properly kept from overflow and leakage from the river would give a place for depositing the refuse materials until filled up. The dam at the upper end, however, is not watertight, and its crest is about level with ordinary high water, and beside this the high water of the past two or three springs has cut around the end of the crib work so that at each recurrence of high water the basin has been flooded, and on some occasions the current has run through the basin with sufficient force to wash out and carry away a considerable portion of the materials then deposited there. The amount of sludge and waste which had accumulated in the basin at the date of my last inspection was but a fraction of that which the mills must have produced since the accumulation began, i. e. since the basin was constructed three years ago. Assuming the density of the lime and bleach sludges to be each 90 lbs. per cu. ft. exclusive of the contained water, and of the black-ash waste to be 50 lbs. per cu. ft., the above determinations of the quantities of refuse discharged from the mills would give the following:

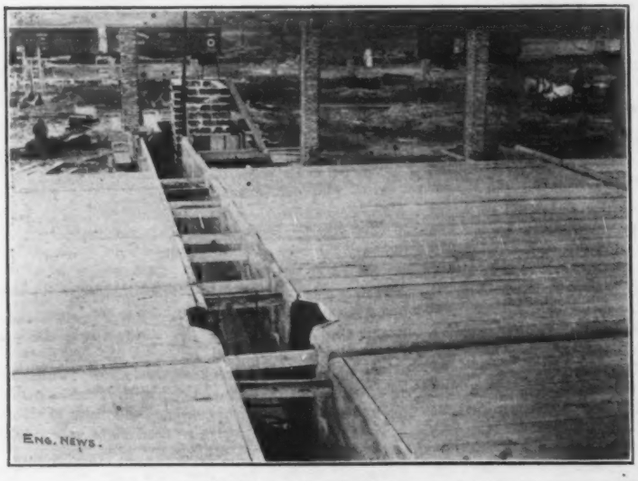


FIG. 12. VIEW OF COLUMN AND GIRDER FORMS.

FIG. 13. INTERIOR VIEW OF MAIN BUILDING.

FIG. 14. EXTERIOR VIEW OF MAIN BUILDING.

Amount of Refuse Discharged from Willsboro Mills.

Kind of Refuse.	Weight per day, lbs.	Weight per annum, lbs.	Volume per annum, cu. ft.
Lime Sludge	26,000	9,100,000	101,100
Bleach "	3,000	1,050,000	11,600
Black-ash Waste..	15,000	5,250,000	105,000
Totals	44,000	15,400,000	217,700

This aggregation, which does not include the wood waste and siftings from the chipped wood, nor cinders, both of which are variable and uncertain, nor the lost soda-ash, which goes into solution in the stream, is sufficient to fill an acre of land 5 ft. deep in a year of 350 running days.

The basin is formed by crib-work, which Professor Landreth found was so leaky as to allow a stream of water to pass through it, "very strongly charged with alkaline matter, apparently soda, and with a chlorine odor."

Some six or eight years ago the company, on complaint of the State Forest, Fish and Game Commission, installed a detention basin for the sludge and other refuse, and this not remedying the nuisance, the Commission brought suit for abatement in 1900, alleging injury to fish in the lake. Before the action came to trial an agreement to build a basin to retain the mill wastes was made by the company, but instead of providing water-tight dams to form the basin, the leaky crib-work already mentioned was built. Complaints from the Commission in 1901 led to an extension of the crib-work, but with no change in its character.

Inspections of the Boquet River showed chalky deposits at two or three places where the water was quiet. In November, 1903, the river and lake were low, exposing a deposit of wood chips, screenings, bark and black-ash waste which in some places was 2 or 3 ft. deep and which had a total area of about two acres. Most of the wood refuse was water logged.

It was found that the complaints of a nuisance along the lake shore had their chief basis "in the fouling of the shore by large amounts of dead and decaying aquatic vegetation that had been cast ashore by the waves" and had been left ashore to decay after falls in the lake level. On being exposed this "material dried out and the fine mineral matter gave the coating a nearly white appearance," in the form of a band along the shore which "could be seen from a long distance." The close resemblance of this material to pulp waste gave the people the impression that the deposit came from the mills. Offensive decaying matter, of aquatic origin, was also found floating near the shore and being dashed on the rocks at times, rendering the water unfit for any use.

THE AU SABLE RIVER AND THE AU SABLE FORKS SULPHITE PULP AND PAPER MILLS.

The Boquet River has two branches, rising on Mt. Marcy, with lengths of 38 and 34 miles, respectively, besides a considerable length of main river. The latter flows through Au Sable Chasm, below Keeseville, joining Lake Champlain four miles north of Port Kent and ten miles south of Plattsburg. The river has a hilly and mountainous drainage area of 490 sq. miles, on which there is a permanent population of about 11,000, and a summer population two or three times as great, mostly on the shores of the streams and lakes in the drainage area. Lake Placid, the largest of the villages, has a sewerage system, and has been ordered by the State Department of Health to provide sewage treatment works. At Au Sable Forks and Keeseville some sewers discharge into the river. The pollution from these sewers has no special relation to the complaints of nuisance under investigation.

The chief source of pollution of the river by industrial wastes is the pulp and paper plant of the J. & J. Rogers Co.,* at Au Sable Forks. About 100 cords of wood per day are used for making spruce pulp and manila papers, and about 200 men are employed for both purposes. The sulphite of lime process is used in the pulp mill. By this process "the encrusting lignin of the wood is dissolved by cooking or digesting the chipped wood in a weak solution of bi-sulphite of lime, liberating the fiber, which is largely cellulose."

The chipped and screened wood is treated in five digesters, four of which are 10 ft. in diameter and 30 ft. high, and one 14 × 38 ft. The treatment is described in the report as follows:

The sulphate liquor used for cooking the wood is formed by passing the fumes of burning sulphur through lime water, the sulphurous acid formed uniting with the lime to form bi-sulphite of lime with small amounts of sulphate of lime and some uncombined free sulphurous acid. After digesting for several hours until the fiber has been sufficiently separated or loosened from its encrusting lignin, the contents of the digester are blown out into tanks where the waste liquor, containing the dissolved portions of the wood, in combination with the sulphite of lime, and the remaining free sulphurous acid that has not been recovered, is washed out and discharged into the river or elsewhere, leaving the fibrous pulp alone in the tanks. In this process of washing the pulp a considerable amount of the finer sizes of pulp generally escapes by passing through the screens.

Assuming that the highest available yield of pulp is secured, the waste wood refuse remaining would amount to 1,500 lbs. per cord of wood treated, or 150,000 lbs. per day. Associated with this is nearly all the sulphite of lime used as an agent and such free sulphurous acid as is not recovered. The report continues:

These compounds of sulphite of lime and wood lignin are insoluble in dilute solution such as occurs as soon as the waste liquor is diluted by the river water, and accordingly precipitate out of the river water as soon as the water reaches a quiet condition, as in the lower ponds or in the lake. As the ponds are well scoured at times of freshet, the accumulations of precipitated wood matters from solution are probably mostly carried out into the lake when such freshets occur. The free sulphurous acid contained in the waste sulphite liquors acts as an antiseptic and prevents the decomposition of the woody compounds while the sulphurous acid remains, but as soon as this is diluted in the river this antiseptic action ceases and the woody compounds decompose, but, from their nature, very slowly. Robbed of its moisture this woody precipitate comprises from 80 to 85% of organic matter, and from 15 to 20% of mineral matter, the latter containing not only the remaining lime and sulphur, but also the natural wood-ash from the lignin.

Assuming that the sulphur is 4% and the lime 10% "of the wood waste, the aggregate dry weight of refuse in the waste liquor would be as follows:

	Weight in pounds per Day.	Weight in pounds per Year (350 days).
Wood waste	150,000	52,500,000
Sulphur	6,000	2,100,000
Lime	15,000	5,250,000
Total	171,000	59,850,000

Commenting on these figures, Professor Landreth says:

These are very conservative, minimum estimates; the actual amount of the several kinds of refuse is very likely in excess of the above figures. It is to be understood, of course, that the sulphur and the lime are not assumed to be in a free state, but both are doubtless combined with the woody matter, forming more or less complex and somewhat unstable compounds. These compounds on entering the river water are slowly decomposed and other more stable compounds formed in their place. The color of the waste liquor as it comes from the digesters and from the washing tanks is a bright, clear liquor of a brown or clear coffee color; later it changes in color to a blackish and more turbid appearance, largely due to changes in the sulphur compounds. The odors undergo corresponding changes; the acrid, sulphurous odor which is so pronounced near the mill gradually disappears and in its place a sweetish, slightly pungent odor, characteristic of sulphite refuse, gradually develops as one goes farther down stream. This odor while not offensive to some persons is extremely nauseating to others; its character and strength appear to vary considerably with the stage of the river, and doubtless with the temperature and degree of dilution in the stream. In the lower reaches of the river, below the Au Sable Chasm, where the water is very slack and precipitation very evident, the odor was almost offensive, and at times it is said to be very offensive.

Keeseville, a village of 2,200 population, located along the river just above Au Sable Chasm, is seriously affected by the pulp mill waste, which damages its public water supply, fouls the surface and banks of the river and produces disagreeable odors.

The water-works were built by the village in 1883, and take water from the river without filtration. The works have cost about $40,000, and for a number of years paid operating expenses and interest, but of late the consumers and revenue have fallen off, owing to the bad quality of the water. It is said that the water was "clear, pure and satisfactory" until after the pulp mill had been running a year. Analyses made on Sept. 15, 1899, by Dr. Willis G. Tucker, Chemist of the State Department of Health, showed that water from the west branch of the river at Wilmington and above the mills, contained 5.4 parts of total solids and 1.8 parts of mineral matter per 100,000, as compared with 23.2 and 7 parts, respectively, in water from the intake at Keeseville. Frequent stoppages of service pipes with solid matter from the water are reported. A section of such a pipe and also "sludge" from the suction chamber of one of the water-works pumps were examined by Professor Landreth. The deposit from the pump "contained a large amount of slimy wood sludge and pulp with a variety of forms of vegetable life in which the fungus Crenothrix or the so-called 'iron-bacteria' was abundant." The deposit had a rank odor. The deposit in the pipe was similar in character (see Mr. Whipple's report below.—Ed.) with more iron oxide present. The pipe was completely clogged against a working pressure of 75 lbs. per sq. in. In December, 1903, Mr. M. A. Thomas, formerly superintendent of the village water-works, wrote:

Our whole water system is practically ruined except for fire purposes and for washing, and there is great complaint of the water turning the clothes that are washed yellow, and some families will not even wash with it, and no one can drink it.

Propositions for a new water supply at the expense of the company have been made by both the owners of the mills and the village, but no agreement between the two parties has been effected. It is desirable, however, that the pollution should be abated, since it seriously effects other rights, both public and private, than those pertaining to the village water supply. The company appreciates this and has made repeated efforts to discover a satisfactory method of disposing of its

*Incorporated as the Rogers Iron Co. in 1871 and reincorporated under its present name and as a domestic corporation in 1893. James Rogers is president of the company and Henry Rogers is manager of the mills; both of Au Sable Forks.

wastes "at a cost which would not be prohibitory." Of the difficulties of the problem and the solutions already attempted and the obligations of the company, Professor Landreth says:

It is proper to state that the treatment of refuse sulphite liquor presents one of the most difficult problems in applied industrial chemistry of waste products. Carrying, as this waste material does, more than one-half the total weight of the raw material, it is evident that it would not be allowed to run to waste if any feasible means were known by which it could be utilized. This, however, does not excuse those who, by its discharge, pollute streams and bodies of water and thereby impair or destroy the interests of others. If the profitable utilization of this material is not possible, then its disposal, even at heavy expense, by means that shall not infringe either public or private rights, is the evident duty of whoever would use the sulphite process, and the same general principle is clearly true for all manufacturing refuse.

Following the official examination of the pollution of the Keeseville water supply by Mr. C. W. Adams, Consulting Engineer, for this Department in September, 1899, the J. & J. Rogers Co. commenced experiments to devise a method by which the sulphite liquor could be treated so as not to pollute the river. The first plan attempted was, I think, to treat the waste liquor with marl brought from a distance; this failing, the liquor was then pumped up onto extensive sand plains near the mills but many feet above them and the river. For a time this appeared to serve the purpose, but soon the sand became saturated and, as little or no effective reduction of the organic matter can occur in the soil, the liquor presently began to leach out of the side of the hill and enter the stream in a blacker and more offensive state than when fresh from the digesters or washing tanks. The company then experimented with a plan by which it was proposed to evaporate the water in the liquor by spraying it into the air to a considerable height and in the form of fine spray. The company then engaged a chemist to study the question of the chemical recovery of some of the contained materials. I am not informed, but I infer nothing came of this as I have just been advised by Mr. James Rogers, the president of the company, that an experimental plant capable of treating about 10% of the total output of refuse liquor has been contracted for, and will be erected and in operation within a month. This plan contemplates the evaporation of the contained water in the waste liquor by artificial heat, and the use of the concentrated or dried product for the extraction of some of the contained wood products. If this plant succeeds, it is proposed to erect a plant capable of treating the entire output of waste liquor. Such a plant is stated will cost about $30,000. I did not learn enough of the details of what is proposed to form an opinion as to the probable success of the undertaking as a commercially economical means of abating the pollution. At most this is a question of greater importance to the company than to the Department or the public. It is certainly possible to stop the discharge of waste liquor into the river, for if no better plan is available the liquor can be evaporated and burned.

RELATION BETWEEN THE DISCHARGE OF REFUSE FROM THE PULP MILLS AT WILLSBORO AND AU SABLE FORKS AND THE POLLUTION OF THE LAKE.

The direct pollution from the pulp mills needs no further discussion, as its nature and the responsibility for it are obvious. The difficult question remaining for discussion is the nuisance arising from the growth and decay of aquatic vegetation and the relation of the pulp mill refuse thereto. The evidence seems to show there has been more trouble from aquatic growth of late than ever before. These growths were studied by Mr. G. C. Whipple, Assoc. M. Am. Soc. C. E., now of Hazen & Whipple, New York City. On May 13, Mr. Whipple visited the lake shore between Willsboro Point and the Boquet River, the shores of Four Brother Islands, the pulp mill at Willsboro and several points on the Boquet River. On June 23, 1904, he submitted a report which is so interesting, both as relating to this particular investigation and to the more general question of nuisances from algae growth, that we give it (nearly in full) as follows:

REPORT OF GEORGE C. WHIPPLE, ASSOC. M. AM. SOC. C. E., ON NUISANCE CAUSED BY ALGAE GROWTHS ALONG THE SHORE OF LAKE CHAMPLAIN AND THE RELATION THERETO OF PULP MILL WASTES AND OF SEWAGE POLLUTION.

My general conclusions from the investigation are as follows:

The growth of the algae on the shores of Lake Champlain, in the vicinity of Willsboro Pt., is due chiefly to natural causes, and is influenced only to a slight extent by the discharge of the pulp mill wastes. The character of the wastes from the Willsboro mills, where the soda process is used, is such that its effect on the growth of algae cannot be considered as material, although some of the waste products put forth are useable as food by the algae. The character of the wastes from the mills at Au Sable Forks, where the sulphite process is used, is capable of affecting the algae to a much greater extent, and may be an important local contributory factor in stimulating their growth.

On the day of my inspection I found the shore between Willsboro Point and the Boquet River to be quite generally covered with a thick growth of Conferva, chiefly that species known as Conferva floccosa. This plant is one of the green algae, or Chlorophyceae. It grows in the water, as does sea-weed, attached to rocks, stone, wooden piers, logs, etc., and covers them with a brilliant green, moss-like mat of minute filaments, which vibrate with the waves. It was found especially abundant on the rocky portions of the shore where the depth of water was less than about three feet. The growths rarely extended to depths greater than that. It was not found on the sandy or pebbly shores, where the frequent rubbing together of the particles, caused by the waves, prevented its finding a lodgment. Nor was it found on the sandy flats at the mouth of the Boquet River, for the same reason. In the region visited, by far the greater part of the shore was found to be covered with this unsightly algae. In places a green streak on the rocks at the water-line could be observed several hundred feet away. If the plant remained always green it would not be so unattractive, but on decaying it turns brown and gas bubbles are evolved, giving a frothy appearance to the mass, while in extreme cases the odors of decomposition may become noxious. At times, when the wave action is severe, masses of decayed algae may be scattered through the water, and on account of their buoyancy, due to their structure and the gas bubbles entrained, they float on the water as dirty brown patches. Such patches were seen at various places near the shore, and they were especially numerous near the mouth of the Boquet River. Most of the floating masses, however, were composed of Spirogyra and Oscillaria instead of Conferva.

As the lake level lowers the Conferva on the exposed rocks dries into a tough fibrous coating, which at times can be lifted from the stones in sheets of considerable size and thickness. This dried material somewhat resembles papier-maché. When Conferva alone is present the sheets have a silky appearance, but when diatoms are also abundant they become friable and are occasionally ground to a fine powder. When the film is wet by the water splashing up on the shores, the rocks become quite slippery. The thickness of the mat, that is, the length of the Conferva filaments, varied from 1 to 3 ins. Under the microscope each filament was found to be composed of a row of short cylindrical cells placed end to end, and about 0.02 mm. in diameter. The filaments were unbranched. The plant propagates by means of zoospores. These after floating through the water become attached to the rocks and develop into filaments which grow by continued division of the cells in one direction. There is a gelatinous substance which surrounds these rows of cells, and this it is which gives the slimy character to the growth. When the green alga is crushed with the fingers it emits a strong, fishy odor, and its taste is oily and fishy. On decay the odor becomes very offensive.

Aside from the objectionable features above mentioned—it cannot be denied that the presence of this alga on the rocks detracts greatly from the beauties of the lake shore—I know of no practical objection to it from the sanitary standpoint. While it is a nidus for many forms of microscopic life, such as diatoms, desmids, various protozoa, besides animal organisms of a larger size, it would not be a nidus for the germs of water-borne diseases, as some have claimed. In fact, its tendency would be to destroy them.

Besides the Conferva floccosa, which formed the bulk of the algae growth on the stones near the water-line, other filamentous algae were found, namely, Spirogyra and Oscillaria. These were frequently observed as floating masses, and they were found growing upon the shores of Boquet River and on the shores of the lake near the river's mouth. The two genera were found growing together with filaments intertwined. No Conferva floccosa was found on the shores of the Boquet River, but the inspection was not sufficiently extensive to prove its complete absence from that vicinity. The Spirogyra and Oscillaria probably occur at intervals along the shore, especially in the coves. These algae form longer filaments than does the Conferva floccosa, and these are more easily broken off by the wave action; hence their appearance as floating masses. They also are able to grow at somewhat greater depths in the water.

Some of the films examined contained masses of diatoms. Of these Fragilaria was the most prominent genus, but Navicula, Synedra, Melosira, Gomphonema, and many others were found. Desmids and other unicellular algae were also present, as well as some of the protozoa, crustacea, etc.

The samples collected by you in 1903 agreed in their essential features with those collected by me, and showed that the material taken from the lake shore was composed chiefly of masses of Conferva and films of diatoms.

The conditions necessary for the growth of Con[ferva] Spirogyra and similar filamentous fresh-water alg[ae] sunlight, a warm temperature, a suitable foot-hold, [a] tain amount of agitation of the water, and a sufficien[t] ply of food material, including oxygen, carbonic ac[id] various mineral salts. Whether or not Conferva re[quires] the presence of organic matter in solution is, so f[ar] I know, unknown. Some of the filamentous algae are k[nown] to thrive in water which contains almost no dissolv[ed] ganic matter, if carbonic acid be present.

The need of sunlight limits the growth of Confe[rva] depths not exceeding 3 or 4 ft., because the sun rays, [as] they penetrate to greater depths, lose their actinic [rays] very near the surface of the water.

Conferva thrives best in moderately warm water. [This] was illustrated by the variations in the growths ob[served] along the shore on the day of my inspection. There [was] observed a tendency for the heaviest growths to occur on those portions of the shore where the water was com-paratively shallow and where rock surfaces were pre-sented to the sun's rays. The temperature observations made that day (May 13) at the surface of the lake varied from 40 to 60° F. At 9 a. m., the temperature of the water at Ellis's boat landing was 40°, while at 4 p. m. it was 57°. The day was very calm and the water sur-face unruffled; consequently the surface water warmed up rapidly. In rowing along the shore with a thermometer trailing in the water near the surface, it was easy to detect those spots where the water warmed quickest. At times variations of 5° or more were found at points less than a rod apart.

Filamentous algae, like Conferva, grow most luxuriantly where they can obtain an undisturbed foot-hold, as on submerged woodwork, rocks, etc. They are not found on muddy, sandy or gravelly shores unless the water is calm.

The subject of the food supply of the algae is the one with which this report is most immediately concerned. The principal chemical elements involved are carbon, oxygen, hydrogen and nitrogen, with smaller quantities of sulphur, phosphorus, silica, magnesium, iron, potas-sium, etc. Oxygen may be left out of the discussion, as the natural conditions existing along the lake shore are such as to supply all the oxygen required by the algae. The amount of dissolved oxygen in the surface water around the shore is probably always near the point of saturation, unless perhaps during the winter when the ice covers the lake. The carbon used by the plants is acquired largely from dissolved free carbonic acid, and this is in turn derived largely from organic matter which has undergone bacterial decomposition. Nitrogen is acquired chiefly from the nitrates present in the water, although in some instances aquatic plants have the power of taking it from the free ammonia dissolved in the water, and it is quite possible that some plants, living symbiotically with certain bacteria, may even utilize dissolved free nitrogen. The nitrates must be looked upon as the chief source, however, and these are the result of complete bacterial oxidation of organic matter. The carbonates, sulphates and phosphates, potassium, magnesium, iron, etc., which are also needed by the algae, are almost always present in surface waters in quantities sufficient for their growth. The calcium salts are thought to be of less importance for the growth of algae than for the higher plants.

The amount of dissolved free carbonic acid in lake waters depends upon the carbonic acid tension of the atmosphere, the quiescence of the water, and the amount of decomposition of organic matter taking place in the lake. Ordinarily near the surface the amount of CO_2 is from 1 to 3 parts per 1,000,000 by weight. On the day of my inspection I determined the CO_2 at various places in the lake. It varied from 0.7 to 1.9 parts per 1,000,000, and averaged about 1.5. Half way between the Four Brother Islands and the shore it was 1.7. At the mouth of the Boquet River it varied from 0.7 to 1.1. A sample of water taken just above a growing mass of Conferva contained no carbonic acid, the plants having exhausted the supply; 2 ft. away there was 0.7 part, and 10 ft. away, 1.9 parts. In the Boquet River about half a mile below the Willsboro Mills the water contained only 0.3 part per 1,000,000 CO_2, and just below the sedimentation basin there was none present. The effect of the discharge of soda or of lime mud (calcium carbonate) would be to diminish the amount of free carbonic acid in the water.

Much of the free CO_2 found in the water of lakes is derived from decomposition of organic matter at the bottom, especially during those periods when the water there is stagnated by reason of thermal stratification; i. e., during the summer or winter. These stagnation phenomena occur in most deep lakes. To what extent they occur in Lake Champlain I do not definitely know. In June, 1895, however, the water in the middle of the lake opposite Essex was thermally stratified, and a sample collected at the bottom of the lake at the same point was clear, almost colorless and odorless, while a sample of the deposit at the bottom showed clean, gravelly material. The temperature observations were made by me, using the thermophone, and, as they have never been placed on record, I append a copy hereto.

It is quite probable that at other parts of the lake deposits of organic matter exist, which would cause decomposition at the bottom, during periods of summer or

water stagnation. Anything tending to increase these deposits would thus tend to increase the algae growths on the shores. The woody fiber discharged from the pulp mills if it settled to the bottom, would act in this direction. In the absence of air, cellulose even may undergo decomposition and yield CO_2. The influence of bottom decomposition on the amount of dissolved free CO_2 in lake water was well illustrated by observations made in Lake Cadillac in 1901.*

During the summer stagnation period CO_2 accummulated at the bottom and was carried to the surface after the biennial overturn of the water. Thus:

Depth in feet.	Amounts of free CO_2 in parts per 1,000,000. Oct. 11, before the overturn.	Nov. 14, after the overturn.
1	2.6	6.0
10	3.0	
20	10.0	
30	11.0	6.0
40	11.0	
50	19.0	
60	23.0	6.0

Next in importance is the nitrogen. This occurs in natural waters in four forms, namely, as part of organic compounds (i. e., as "albuminoid ammonia"); as ammonium salts ("free ammonia"); as nitrites or nitrates, these forms representing successive stages in the decomposition of organic matter. It is chiefly in the form of nitrates that it is available as plant food.

A sample of water collected on May 13, 6 ft. below the surface of the lake, at a point about half way between the Four Brothers and Willsboro Point, contained nitrogen as follows:

	Parts per 1,000,000.
Albuminoid ammonia	0.094
Free ammonia	0.002
Nitrites	0.000
Nitrates	0.400

Samples collected on May 13, from above and below the mills at Willsboro, gave the following analysis:

	Parts per 1,000,000. Nitrites.	Nitrates.
Boquet River above Willsboro	0.001	0.80
Boquet River below Willsboro	0.001	0.88

The samples were not large enough for determination of nitrogen as free and albuminoid ammonia, but the color of the water gives an approximate idea of the amount of organic matter present. These results are as follows:

	Turbidity.	Color.	Odor.	Alkalinity.	Total Hardness.	Dissolved CO_2.
Boquet River:						
Above Willsboro Mills	3	23	Distinctly vegetable	28	41.5	
Below Willsboro Mills	2	29	Distinctly vegetable	29	37.7	0.3
Lake Champlain:						
Off Fairchild Point	1	10	Very faint vegetable			
Off Jones Point	1	8	Very faint vegetable	44	50.0	
Off Four Brother Islands	1	10	Very faint vegetable	42	45.5	

It will be seen that the amount of organic matter as shown by the color was slightly greater below than above the mills, and was nearly twice that of the lake water. At other seasons the color of the river is doubtless much higher than the figures given.

The soda process of manufacturing wood pulp yields as waste products practically all of the mineral constituents and the nitrogen of the wood; the black ash resulting from the burning of the soda liquor; the lime mud, or calcium carbonate, plus a certain amount of lost soda; the sludge and spent liquors from the bleachery; and wash water containing more or less wood pulp, etc. At rare intervals it may happen that a batch of pulp has to be wasted.

The mills of the New York & Pennsylvania Co., at Willsboro on the Boquet River use the soda process. Your letter of June 16 gives the amount of the waste products, as follows:

	Tons per annum.
Lime sludge (calcium carbonate)	4550
Bleach sludge	925
Black ash waste	2625
Soda ash	175
Besides waste wood, chips, wash water from bleachery tanks, pulp rolls, etc.	

On the day of my inspection the waste products were overflowing to a "detention basin," where the lime sludge and other solid matters were precipitated. There was a considerable flow of a dark colored alkaline waste liquor from this basin into the river. Below the dam of the detention basin there were found deposits of lime sludge, and the mud collected from the bed of the Boquet River near the mouth contained traces of calcium carbonate.

*On the amount of Oxygen and Carbonic Acid Dissolved in Natural Waters, and the Effect of these Gases upon the Occurrence of Microscopic Organisms. By G. C. Whipple and H. N. Parker. Trans. Am. Micro. Soc., May, 1902.

The deposit which you sent me from Mr. Ellis's water tank was chiefly calcium carbonate in a finely divided state. From the various data and analysis it is quite evident to me that this lime sludge is not satisfactorily disposed of, but is at times allowed to enter the lake in considerable quantities. The complaint of Mr. Ellis that the lime sludge enters his water supply seems to be substantiated by my investigations; and this fact sheds some light on the distance to which the waste products from the mills may extend into the lake.

Although the waste products from the Willsboro mills are very large, I can see no reason for believing that they contribute materially to the growth of the algae on the shores of the lake. The lime sludge and soda ash would tend to reduce the amount of free carbonic acid in the lake water. The various mineral salts of the wood naturally contain elements usable as food by the algae, but the dilution of these substances by the water of the lake is so great that they do not exert a controlling influence on the algae. Their influence may be considered as contributory, but I am unable to measure its value from the data at hand. The amount of wood pulp discharged from these mills is too small to be of significant effect in connection with the algae growths. The thin films found on the stones of the lake shore between the Boquet River and Willsboro Point show no signs of wood pulp, but are due entirely to growths of microscopic organisms.

The mills at Au Sable Forks present a more serious condition. Here I am informed 100 cords of wood per day are treated by the sulphite process. This involves an enormous waste of the soluble portions of the wood, which you state amounts to between 75 and 90 tons a day. These substances are not altered by burning, as they are in the soda process, and the sulphurous acid tends to prevent oxidation; hence they are discharged in a condition much more likely to undergo decomposition. Settling as they do upon the bottom of the river and lake they slowly decompose, and, if the deposits are sufficiently thick, or if they occur where the water is so deep that stagnation occurs, the decomposition takes place under anaerobic conditions, resulting in the production of carbonic acid and other substances necessary to algal life. The sulphurous acid discharged also tends to lower the amount of dissolved oxygen in the water, thus favoring anaerobic decomposition. During the winter when the river and lake are frozen over, the dissolved gases may accumulate and stimulate the growth of organisms after the ice breaks up in the spring.

The sample which you collected from the ¾-in. service pipe in Keeseville, in December, 1903, was instructive. It was a leathery film composed largely of wood fiber, bound together by the organisms known at Leptothrix and Crenothrix, and containing a large amount of iron. Here was a definite case where the deposit of wood pulp had fostered the growth of these organisms to such an extent as to naturally affect the flow of water in the pipe. There is little doubt in my mind that the partial anaerobic conditions required by the organisms mentioned were favored by if not entirely due to the presence of the wood pulp deposits in the pipe.

On May 13 I collected samples of water from several places in Lake Champlain, the analysis of which are given on the accompanying sheet. The results are not different from analysis of many lake waters where algae thrive on the shores even more vigorously than in Lake Champlain. There are few data available as to the occurrence of the free floating algae, or Plankton, in Lake Champlain. In 1895 the water of the lake from Port Kent to the upper end was filled with a heavy growth of Dinobryon. On May 13, the day of my recent visit, there was floating on the surface a thin film which looked like dust, or pollen, but which was a collection of Coelosphaerium and Clathrocystis. It is apparent, therefore, that the lake water is of itself capable of sustaining growths of algae.

As a general proposition, however, it is safe to say that the constantly increasing population on the lake, the greater amounts of sewage and trade wastes which it is receiving, are factors which will tend to encourage the growth of algae, and intensify the present unsightly conditions along the shores, unless they are controlled. Among these stimulating causes the discharges from the pulp mills, especially from those mills where the sulphite process is used, may be included; but the extent of their influence cannot be determined without a more extensive biological and chemical survey than I have had an opportunity to make.

CONCLUSIONS AND RECOMMENDATIONS.

Professor Landreth's conclusions and recommendations were as follows:

(1) The natural pollution from the population residing on the drainage areas of the Boquet and Au Sable Rivers is not an important factor in the conditions complained of.

(2) The carbonate of lime, bleach-sluge, black-ash waste, etc., aggregating upwards of 44,000 lbs. per day or 15,000,000 lbs. per annum (dry weight), discharged from the Willsboro mills of the New York & Pennsylvania Co. are not properly retained in the present sludge basin, and this sludge basin is not constructed in accordance with the agreement entered into on Feb. 12, 1901, between the New York & Pennsylvania Co. and the State Forest, Fish & Game Commission, as a basis for the withdrawal of an action by the said commission against the said company.

(3) The effect of the black-ash waste, wood refuse and cinders which are discharged or allowed to escape from this mill, appears to be confined mainly to the river at its mouth and to the lake shore immediately adjacent; although the slow decomposition of the wood refuse undoubtedly contributes, along with the black-ash waste, to the stock of carbonic dioxide which is the chief source of food for the vegetable life which thrives abundantly along the lake shores.

(4) The large amount of carbonate of lime discharged from this mill in its impalpable form as a precipitated chemical appears to be carried to considerable distances from the mouth of the river, and within the region of its transportation appears to impair the quality of the lake water for potable purposes.

(5) No fiber or pulp from the Willsboro mills was discovered in the lake shore deposits, which form one of the chief grounds of complaint.

(6) The extensive accumulations and deposits of offensive material along the lake shore at nearly all points examined are due to the decomposition of masses of aquatic microorganisms—vegetable by classification—mainly consisting of different species of green algae and diatoms. The gray or whitish coating on the rocks and stones giving the light banded appearance along the lake shore above water-line, is due to the drying and bleaching out of this organic matter, intensified to some extent by mineral matter entrained by it, apparently silicious matter and carbonate of lime.

(7) Dr. Whipple sees no reason to believe that the waste products from the Willsboro mills contribute materially to the growth of the algae on the shores of the lake.

(8) The discharge of refuse sulphite liquor, lost fiber and other wood waste from the sulphite pulp mills of the J. & J. Rogers Co., at Au Sable Forks, amounting to at least 171,000 lbs. per day or about 60,000,000 lbs. per annum (dry weight), is the cause of serious pollution not only in the Au Sable River, but in the lake.

(9) The pollution of the Au Sable River from the sulphite pulp mills at Au Sable Forks discolors the water, gives it a strong odor which is offensive to many people, fouls the banks, has seriously injured the public water supply of the village of Keeseville, and renders the river water generally unfit for domestic purposes.

(10) The refuse discharged into the river from the mills is for the most part carried into the lake partly throughout the year and partly at times of freshet. Settling and accumulating on the bottom, being mainly organic woody matter, it contributes materially by its decomposition to the stock of plant food for the algae and other microorganisms which form the chief ground of complaint concerning the lake shore.

(11) The accumulations and deposit of decomposed organic matter along the lake shore are detrimental, not only through the production of objectionable odors and the injury to the potability of the lake water when carbonate of lime deposits are washed up, but also in the serious defacement of the shore and of boats and docks.

(12) The discharge of all solid refuse from the Willsboro mills can be entirely avoided, without unreasonable cost, by either of two plans: First, by the reconstruction or improvement of its present sludge basin rendering it water-tight and safe against injury or inroads from high water and ice, so that the basin should at all times remain crest-full of liquid waste, thus giving an opportunity for complete sedimentation of the solid matters until the basin becomes nearly filled with solid matter which it should do at the rate of upwards of 8,000 cu. yds. per annum. When this basin becomes filled with solid matter it would then be necessary to construct a new one. The second or alternate plan would be to reconstruct or improve the present sludge basin as in the above plan, but to relieve it of the burden of storing up the carbonate of lime, which represents by far the greater part of the refuse, by installing and operating at the mills a suitable process for the recovery of lime from the waste carbonate of lime. I do not know of any really serious obstacle to the use or success of such a process, which should if reasonably successful recover a large proportion of the lime needed for the causticising of the soda-ash, and at a cost not much if any greater than for the present supply of lime, with the advantage of thus taking care of the largest item of refuse.

There may be obstacles or reasons against the introduction of this second plan of which I am not aware; but in any event the first plan is beyond question feasible.

(13) The discharge of refuse sulphite liquor, lost fiber, and other wood waste from the sulphite mills at Au Sable Forks can also be avoided, and at a cost which at the worst would not be prohibitory. Even if the company should not succeed in developing a system whereby it might recover as waste products some of the woody materials now lost, it is still feasible to devise a system by which the refuse liquor may be evaporated and its solid constituents burned along with the other forms of wood waste, and at a cost which would not be prohibitory to operate.

(14) The discharge of sewage from the several municipalities on the lake and on its tributary streams constitutes an element in the development of the objectionable aquatic growths along the lake shore, though less extensive than the discharge of pulp mill refuse, and it also presents an element of danger to the potability of the water of the lake.

RECOMMENDATIONS.

Following the above conclusions, I beg to submit for your consideration the following recommendations:

(1) That the New York & Pennsylvania Co. be required under Section 6 of the Public Health law, or under other general authority, to permanently discontinue and cease, within a reasonable length of time from the date of notification, the discharge or the escape from its Willsboro mills, of all lime-sludge, bleach-sludge, black-ash waste, lost fiber, wood waste, cinders, and all other forms of pulp-mill waste, into the Boquet River or any tributary stream, or into Lake Champlain.

(2) That the J. & J. Rogers Co. be required under Section 6 of the Public Health law, or under other general authority, to permanently discontinue and cease, within a reasonable length of time from the date of notification, the discharge or escape from its pulp and paper mills at Au Sable Forks, of all waste sulphite liquor and washings, and all lost pulp, wood waste, paper-mill waste, bleach-sludge and all other forms of pulp-mill and paper-mill refuse, into the Au Sable River or tributary stream, or into any place where it may find its way into the said river or tributary stream.

(3) That in view of the importance of the purity of the waters and the shores of Lake Champlain and Lake George, the laws, regulations and authority of this Department, relating to the discharge of sewage into public waters, be strictly enforced with regard to these lakes and all tributary streams.

(4) That, if upon investigation by this Department it shall be found that the pulp mills at Ticonderoga are discharging or are allowing to escape into any stream, pulp-mill refuse of any kind, the same orders be issued to the owners and operators of these mills as are recommended above for the Willsboro mills.

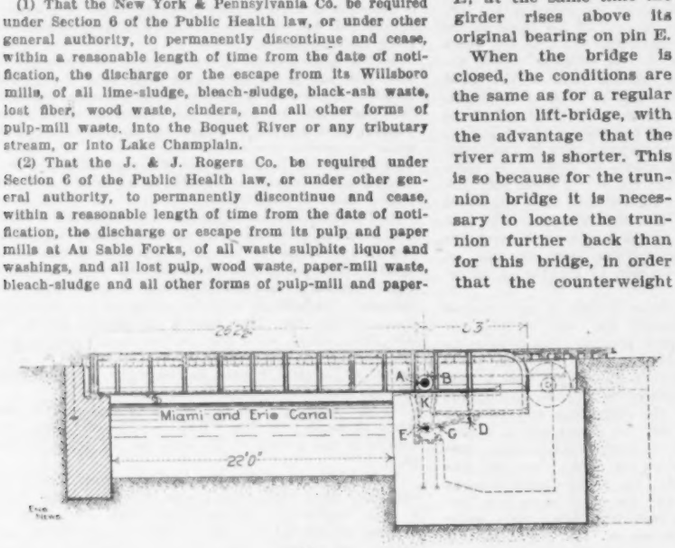
SHORT SPAN BASCULE BRIDGE ON THE PITTSBURG FORT WAYNE & CHICAGO RY.

The western division of the Pittsburg, Fort Wayne & Chicago Ry. crosses the Miami & Erie Canal at Delphos, O., by a double-track, short-span, single-leaf bascule bridge of peculiar design. The clear width of waterway is 22 ft., and the bridge has a river arm 26 ft. 2½ ins. long, and tail 8 ft. 3 ins. long, making the total length 34 ft. 5½ ins. It is a plate-girder deck structure, with four girders 38 ins. deep. The design is shown in Figs. 1 and 2.

The principal features of this type of lift-bridge are as follows: The tail end of the bridge is counterweighted so that the center of gravity of the whole movable dead weight coincides with the center of the pivot shaft A. The wheels B are keyed to the shaft A, and the main girders pivot on this shaft. The swinging strut C is connected at one end to the movable girder by a pin D, and the other end is attached to a pin E in the masonry. When the bridge is closed, the main girder bears on the pin E, by means of a pedestal, K, and the wheels B are raised slightly off the tracks F, so that the live load on the bridge is carried directly by pin E to the masonry. The wheels are double-flanged, 18 ins. diameter, and 7 ins. wide on the tread.

The break in the floor is made on the river side of the shaft, so that no live load comes upon the tail, and no tail lock is required. The rail of the movable part of the bridge is directly fastened to the steel stringers at G and H, and bears on the stationary ties when the bridge is closed. At G the statibnary rail is anchored to the masonry, so that the rail lock when applied forms an anchorage for the bridge. To open the bridge, the rail locks are withdrawn, then the shaft A is pulled back horizontally by the operating strut J. The movable span now first rotates around pin E until the wheels B are in full bearing on the tracks F. Continuing the motion, the wheels travel horizontally on these tracks, while the pin D of the girder rotates around pin E; at the same time the girder rises above its original bearing on pin E.

When the bridge is closed, the conditions are the same as for a regular trunnion lift-bridge, with the advantage that the river arm is shorter. This is so because for the trunnion bridge it is necessary to locate the trunnion further back than for this bridge, in order that the counterweight may not interfere with the masonry in opening the bridge. The bridge is operated by hand, and the gearing is arranged so that one man can open or close the bridge in 2½ minutes under ordinary conditions. The bridge can be operated as a unit or as two separate single track bridges. It has been in constant use under heavy traffic, for nearly four years, and is reported to have given entire satisfaction.



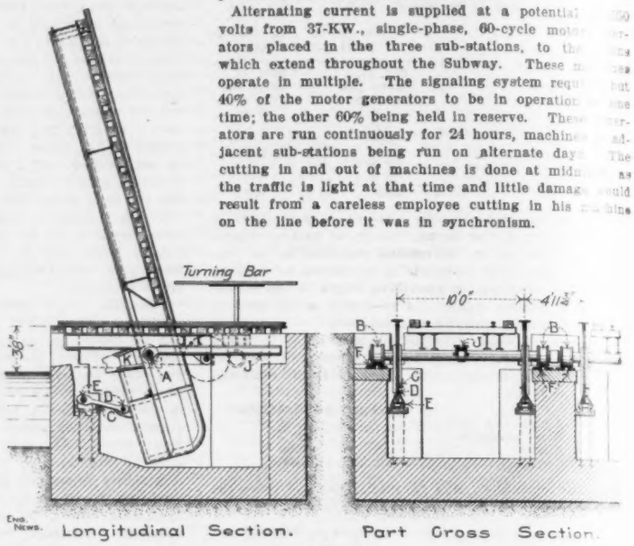


Fig. 1. Fig. 2.

SHORT SPAN BASCULE BRIDGE AT DELPHOS, O.; PITTSBURG, FORT WAYNE & CHICAGO RY.

C. L. Strobel, Chicago, Contracting Engineer; Theodore Rall, Chicago, Inventor.

The bridge was designed and built in 1901 by Mr. C. L. Strobel, contracting engineer, of Chicago. The design is termed the "retractile lift" bridge, and was invented and patented by Mr. Theodore Rall, who is Mr. Strobel's principal assistant engineer.

A type of "rolling swing" drawbridge over this same canal was described in our issue of Oct. 22, 1903. The bridge was pivoted at one end, and had its other end supported by a bent, with rollers traveling on a curved track laid on the bed of the canal.

SIGNALING IN THE NEW YORK SUBWAY.*

By J. M. Waldron.†

The Subway had been designed, the greater portion of it built, a considerable quantity of the track laid and a great many of the switches placed, before the question of signaling and interlocking was taken up in a practical manner. The space was then found to be so limited that practically the only standard signaling and interlocking apparatus which could be used, were detector-bars and detector-bar clips. Everything else required new design. To develop an entirely new system of block signaling under favorable conditions is a difficult undertaking, but to do this when it was necessary to redesign all apparatus known to the art of signaling, and make the system provide for handling, in a safe and satisfactory manner, the greatest passenger traffic known in the history of the world was a stupendous undertaking. How well this task has been accomplished is now shown by our monthly record of but thirteen failures to more than 4,206,720 signal movements, or one failure to 323,594 movements. The record speaks for itself.

The low voltage gravity battery, commonly used for track circuits, has always been a source of more or less trouble in automatic signal work; but especially has this been the case since railroads have been paralleled and crossed by electric roads. On account of the impossibility of making an automatic block signalling system work successfully with a direct current track circuit, when the running rails were used for a return [illegible] propulsion current for trains, a new system was [illegible] in which the signal operating current was of such character that the instruments designed to be operated [illegible] would not be affected by the propulsion current. [illegible] found that the 60 cycle alternating current would flow through the tracks with the return direct current [illegible] that a relay could be made which would be operated [illegible] alternating current, and not respond to a direct [illegible] nor would a direct current hold the relay in the [illegible] position after it had once been cleared.

Alternating current is supplied at a potential [illegible] volts from 37-KW., single-phase, 60-cycle motor [illegible] erators placed in the three sub-stations, to the [illegible] which extend throughout the Subway. These [illegible] operate in multiple. The signaling system requires but 40% of the motor generators to be in operation [illegible] time; the other 60% being held in reserve. These [illegible] erators are run continuously for 24 hours, machines in adjacent sub-stations being run on alternate days. The cutting in and out of machines is done at midnight, as the traffic is light at that time and little damage would result from a careless employee cutting in his machine on the line before it was in synchronism.

As a reserve source of supply of alternating current there is provided at each sub-station a 25-KW. transformer with a ratio of 20 to 1, the secondary coil of these transformers at a potential of 550 volts, is connected to two terminals of a double-throw switch which is on the signal switch-board. By reversing this switch the generator is cut off from the signal mains, and the 60-cycle 550-volt current from the secondary coils of the transformer cut in. The current is supplied to the primary coils of these transformers direct from the turbo-generators which are used for lighting purposes at a potential of 11,000 volts. Thus, there are two independent sources for the alternating current track circuits, each of which has boilers, engines and dynamos in triplicate. This makes the supply as nearly constant as is obtainable.

At each signal is a transformer, the primary coils of which are connected to the alternating current mains; cut-outs with 3-ampere fuses are placed in each of these connections. These transformers have two secondary coils, one with a ratio of 10 to 1 for lighting the signals, the other with a ratio of 50 to 1 for the track circuits. This gives about 8 volts between the running rails of the track at the transformer end of the track circuit, and about 7 volts across the terminals of the relays. As the relays are adjusted to pick up at 3 volts, this leaves a working margin of about 4 volts or a little over 100%. A 50-ampere fuse is placed in each connection between the block signal rail and the instruments in the mechanism case. For the month of February there were but three failures on account of alternating current for 4,206,720 signal movements.

A delicate instrument is not required to detect the condition of a track circuit, as the intensity of the spark when the rails are joined by a wire, readily indicates the approximate amount of current passing through, and after a little practice, a signal maintainer can determine this within reasonable limits. One of the peculiarities of the alternating track circuit, is the tenacity with which it persists in operating the signals to the exclusion of any influence from foreign currents, whether from electric trains or other sources.

A resistance grid of 1 ohm is placed in series with the track circuit at the transformer end and another at the relay end of the block, to prevent the flow of an excessive amount of alternating current at the transformer, and also to prevent a harmful amount of direct current through the apparatus. An impedance coil of very low ohmic resistance, is placed in multiple with the alternating current relay; the chief object of which is to permit the passage of all direct current which returns through this path, and relieve the relay winding of this extra duty.

For lighting purposes each signal is provided with two 60-volt, 3-c. p. lamps in multiple, which receive their current direct from special secondary coils in the track transformers. These lamps give little trouble, as five

*A paper read at the meeting of the Railway Signal Association in New York City, May 23.

†Signal Engineer, Interborough Rapid Transit Co.

...this operation with about 1,500 lamps, and no detention on account of lamps burning out, amply demonstrate. The functions of the alternating current end with the track circuits, and the lighting of the signals; all other relays, signal valves, automatic stop valves and switch valves are operated by means of direct current from storage batteries, at a potential of 16 volts. These batteries are connected in multiple to two mains which extend throughout the length of the Subway. Each battery unit consists of two sets of eight storage battery cells, one motor generator, one switch board with the necessary starting and controlling rheostats, charging and discharging switches, ammeters, volt-meters, overload discharging circuit-breakers, etc. Battery stations are located in or near interlocking towers; all batteries are carefully inspected and charged each day, each set is given a charge of about 25% in excess of its discharge of the previous day. The capacity of these batteries is such that there is always enough current on hand for five days' operation. Current for lighting the towers and driving the motor-generators which charge the storage batteries is taken from the third rail. Battery stations are so situated that should any one be disabled, the adjacent station would supply all necessary current to keep the signals and interlockings running until the disabled batteries could be replaced.

One of the battery stations is situated on the Manhattan Valley Viaduct about 75 ft. above the street level, at a point where it has full benefit of the cold winds which come across the Hudson from northern New Jersey. No attempt was made to heat this enclosure, yet the operation of this battery was perfect during the coldest days of the winter.

Each night a careful inspection of the switches, signals, stops, junction-boxes, relays, impedance coils, transformers, lamps, fuses and track wiring is made, and all Weber rail-joints are swept carefully to remove all conducting material, such as splinters from brake shoes, etc., which lodge across the rail insulation. I attribute the great success of the system to these careful nightly inspections.

The best quality of rubber-insulated copper wire was used throughout the system. The alternating current mains are supported by glass insulators, which are attached to the tops of the knee braces on the center line of columns, about 20-ft. apart. The cables and battery wires are supported by span wires along the centre line of columns on the side opposite the main air pipe. Wooden conduits are used for all wires and cables connected with the signals and interlockings. This conduit is of a good quality yellow pine, and was dipped in asphaltum paint before being installed; this is giving perfect satisfaction as there are no short circuits between it and the third rail. We cannot say as much for the iron conduit, which has been used for other purposes, as this has been short-circuited a number of times with the third rail, and the wires and conduits burned off.

The compressed air for throwing switches and clearing signals and automatic stops, is taken from the main pipeline which extends throughout the length of the Subway. This main line is placed along the center line of columns, just at the bottom of the knee braces. The pipe used in the construction of this air main is 2-in. extra heavy galvanized iron with extra heavy galvanized fittings. Bends are used to take care of expansion and contraction in the pipe, and the customary expansion joints are used where it was found unadvisable to use expansion bends. All branch pipes leading from the main air pipe to the various stops, signals and switches, are ½-in. heavy, galvanized. The manifold condensers for cooling the air after it has left the compressors, are placed in the Subway opposite the sub-stations. Between these condensers and the sub-stations, under the city streets, are two lines of 3-in. extra heavy, galvanized pipe, surrounded by three inches of concrete. These precautions were taken to avoid having this pipe damaged by men digging up the streets to repair gas, water and other pipes.

The air compressors for supplying the compressed air, are situated in the basements of the sub-stations, one in each station. These are motor-driven, automatically controlled machines, each with a capacity of 230 cu. ft. of air per minute. All compressors are on the air line at all times, but the automatic controlling device on each compressor is adjusted so as to shut down the machine when the air pressure reaches a predetermined point, and start it after the pressure has fallen to a predetermined point which is considered the minimum pressure allowable. The device which automatically controls the compressor, also automatically cuts in the supply of water which is necessary for cooling purposes, so that no water is wasted. These compressors are always started against no load, and it is only when they have reached their rated speed, that the load is automatically cut in. This arrangement is considered the most economical in the use of power and of water, which has yet been devised for the operation of air compressors.

At points where the different signal repairmen make their headquarters, recording air gages and recording A. C. volt meters are located; this makes it possible for a repairman at all times to know the air pressure in the pipes, and the voltage on the A. C. mains.

There are interlocking plants at forty different points in the Subway system. Most of these interlockings are very busy places. At tower "B," 96th St., during the rush hours of the day, fifty-eight 5-car trains and fifty-seven 8-car trains, or a total of 115 trains are handled each hour, and 58 of these trains are crossed from one track to another. Switches, signals and stops must be operated for every train which passes this point; yet, so well has this been taken care of, that for months there have been no detentions on account of defects in the mechanism.

The block signaling circuits are carried through the interlockings, and all interlocking signals and stops are made semi-automatic. As many of these interlockings are near the ends of station platforms, and must take care of trains passing from the middle track at one end of the station to the middle track at the other end against traffic, it is necessary to make use of a great many special track sections in order to carry through the overlapping system of block signaling, and in addition to this, it is necessary to hold the automatic stop in the clear position until the last car of a passing train has gone by. This necessitates the employment of exceedingly complicated circuits, and these are especially complicated where the circuits of block signaling the middle tracks in both directions are carried through interlockings. It has been quite a task to organize and train a force of men to take care of this system. While most of the men selected for this work have had a number of years of experience on signaling and interlocking work on railroads in all parts of the country, yet, as there were so many entirely new things in our mechanism and the manner of control, it was found necessary to instruct the repairmen in the maintenance of this particular system. In order to do this properly, we have established a school where a number of the men meet one afternoon each week and discuss the many questions in connection with the maintenance of the system. The room where these meetings take place is equipped with blackboards, sections of the different valves, relays and other apparatus. This school is found to be a great help to the men and of vast benefit to our company, as the men are able to give much better service.

You will notice that successful operation of the signaling system requires correct working of the air compressors and alternating current motor-generators, under the jurisdiction of the operators of the sub-stations in which they are located, and of the direct current from storage batteries located in the Subway under control of the signal maintainers.

On the express tracks south of 96th St., and on the local tracks north of that point, where the stations are a considerable distance apart, a complete overlapping system of block signaling is used. At other points on the local tracks, only straight blocking is installed. Automatic trips are used in connection with all overlapping block signals and at all interlocking signals. The automatic trip, as many of you know, is not a new safety device, for it was used more than 30 years ago, but, as it has never been used as extensively on any road as on the Interborough, it will probably interest you to know that our people regard it as one of the best disciplinarians ever introduced on a railroad system. It teaches the motormen that a red signal means "Stop;" if he disregards this warning and runs by the signal, his train will be tripped and if running at a high rate of speed, all motor cars on the train will be tripped. To restore these trips, requires from two to two and one-half minutes. This much of a delay is always detected, whether reported by the motorman or not, and if it occurs during the rush hours the schedule cannot be restored to its normal condition until such periods of the day when traffic is not so heavy.

DISTRIBUTION OF SHEAR OVER SECTION, FOR REINFORCED CONCRETE BEAMS.

By John G. Little.*

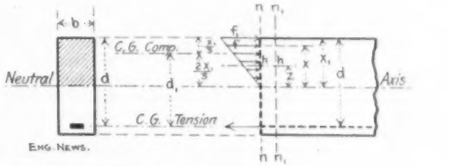
The question of the distribution of shear over the section of a concrete-steel beam seems to have proved troublesome to a number of persons who have attempted to deal with it. This seems a little remarkable as there is nothing in the reasoning of the ordinary analysis for intensity of shear in homogeneous beams that will not apply equally well to any kind of composite beam.

The following solution is presented in the hope that it may be useful to those of your readers who have not solved this problem satisfactorily for themselves. The definitions of symbols have been made general, to bring out the resemblance of the analysis to that for a homogeneous beam, and it will be noticed that the derivation down to and including Eq. 9, and also Eq. 10, without the inserted note, apply as well to a *gold* beam as to one of concrete-steel.

The solution following conforms to the usual assumptions: 1, that stress varies as the deformation; 2, that transverse sections plane before bending are plane after bending; 3, that the compression is taken wholly by the concrete; 4, that the tension is taken wholly by the steel, and, 5, that total tension = total compression; 6, M_o = tens (or comp.) $\times$ d_1.

Consider two planes n and n_1, a unit distance apart. Let

- F = total increment to compression between planes n and n_1 = total increement to tension.
- f_1 = increment to stress in outer fiber between planes n and n_1.
- f = corresponding increment to stress in fiber distant x from neutral axis; $f = f_1 \frac{x}{x_1}$.
- S = total vertical shear on plane n.
- S_h = total horizontal shear on any horizontal plane h — h, whose area is $1 \times b = b$ and whose distance from the neutral axis is z.
- d_1 = distance from c. g. of tension to c. g. of compression.
- i = intensity of shearing stress on plane h — h, = intensity of vertical shear in plane n — n where it is cut by plane h — h.



We know from mechanics,

$$F = \frac{S}{d_1} \qquad (1)$$

and evidently

$$\frac{1}{2} f_1 x_1 b = F \qquad (2)$$

$$\therefore f_1 = \frac{2F}{x_1 b} = \frac{2S}{x_1 d_1 b} \qquad (3)$$

Further,

$$f = \frac{f_1 x}{x_1} \qquad (4)$$

The shear on plane h — h is

$$S_h = \Sigma\, b\, f\, dx \text{ from plane h — h to outer fiber,}$$

$$= \int_z^{x_1} \frac{b f_1 x}{x_1} dx \qquad (5)$$

$$= \frac{b f_1}{2 x_1} (x_1^2 - z^2) \qquad (6)$$

and substituting Eq. 3.

$$S_h = \frac{S}{x_1^2 d_1} (x_1^2 - z^2) \qquad (7)$$

$$= \frac{S}{d_1} \left(1 - \frac{z^2}{x_1^2}\right) \qquad (8)$$

Then the intensity of shearing stress, both vertical and horizontal, at plane h — h, is

$$i = \frac{S_h}{b} = \frac{S}{b d_1} \left(1 - \frac{z^2}{x_1^2}\right) \qquad (9)$$

This is the equation of a parabola whose maximum ordinate is at the neutral axis, where $z = 0$, and the shearing intensity is simply $\frac{S}{b\, d_1}$. If the steel takes all the tension, the intensity of shear is constant from the neutral axis to the steel and is represented by

$$i_{max.} = \frac{S}{b d_1} \qquad (10)$$

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LOCOMOTIVES OF HIGH POWER.

At the International Railway Congress, held at Washington, D. C., last week, two important papers were presented on the subject of high-power locomotives for passenger and freight service. Some notes on the discussion are given in our report of the meeting, but we give below the conclusions presented in the two papers:

CONCLUSIONS OF MR. T. E. MUHLFELD (General Superintendent of Motive Power, Baltimore & Ohio Ry.)—1. Locomotives of great power, within the present gage, clearance and weight limits, may be designed and constructed to remain effective for several years and produce a higher average speed and tractive power with less cost for locomotive expenses per unit of power developed, than that given by locomotives of large capacity in use to-day or from the previous lighter equipment.

2. The efficiency and economy predicted and anticipated from the use of locomotives of great power have not been attained. Their development has been too rapid on the basis of the theoretical calculations which did not include the necessary factors for practical results, and also owing to the disregard of simplicity in design, substantial maintenance and speed as elements of economy.

3. Locomotives of comparatively recent construction have been built without proper consideration for the use of railway standard designs, specifications, practices and processes which continued and practical experience may have determined to be more suitable and interchangeable than the standards of locomotive builders.

4. The present dead weight should be reduced by the use of design and material which will combine the least weight and greatest desired strength.

5. The elimination of those individual preferences and devices, more or less visionary, which have no real value, by the use of simple, practical design and construction, will produce more satisfactory general results.

6. The motive power department supervision has often been curtailed when extension of organization and direct oversight should have been given to insure the desired performance. Changes in organization and methods have frequently been made in preference to technical education and advancement for the deserving rank and file.

7. The locomotive maintenance and dispatch facilities have not always been developed to meet the proportionate increase in the locomotive dimensions, capacity and requirements, while slow line movement has made it necessary to increase average mileage by reducing delay at terminals during a period when more opportunity for maintenance and handling has been essential.

8. The tonnage hauled per train has frequently precluded the making of an average speed between initial and destination terminals that would be productive of efficiency and economy in locomotive movement.

9. Decreased efficiency has resulted from the irregular transferring and changing of crews of locomotives for long runs. The regular assignment of crews to locomotives and of suitable locomotives to shorter runs on regular districts, should accomplish the best results.

10. Provision for the cleanliness and care of employees and equipment on the line and at terminals, should receive more consideration.

11. Personal supervision and investigation should govern in the construction and operation of locomotives of high power, while statistical information and correspondence should be limited and used with caution.

CONCLUSIONS OF MR. E. SAUVAGE (Western Railway, of France.—A. Wheel Loads.—An important point in considering locomotives of great power is the wheel load permissible. Most of the lines of any importance allow at least 7.5 English tons; frequently the limit is 8.5 to 9 tons. It is 10 English tons on several English railways; in the United States there are instances where higher wheel loads are admitted. If we limit ourselves to the continent, wheel loads hardly exceed 9 tons (8.86 English tons). But it is probable that the traffic of trunk lines will require a new increase in the power of locomotives for fast trains, so that it will be desirable to have tracks which can stand wheel loads of 10 tons (9.48 English tons). However, in order not to fatigue the rails too much, it might be specified that this limit of 10 tons (9.48 English tons) is only allowed in the case of locomotives constructed so as to keep within sufficiently narrow limits, at the highest speeds, the variations of load which are produced at each revolution of the wheels.

B. Gage of Track.—The power of locomotives built for tracks of wider gage than the standard which are used in some countries (Spain, Portugal, Ireland, India, Russia) does not exceed that of locomotives running on standard gage tracks. In order to benefit by the wider gage it would be necessary for the track to stand heavier wheel loads.

C. Diameter of Driving Wheels.—The diameter of the wheels rarely exceeds 6 ft. 6⅜ ins. with the fastest locomotives; at most it amounts to 6 ft. 10 11-16 ins. or 7 ft. ⅝-in. Very high speed locomotives often have wheels of a less diameter than 6 ft. 6⅜ ins. This results in more than 300 revolutions per minute, corresponding to a speed of 70.2 miles per hour with wheels of this diameter. It would be desirable not to exceed this limit, in order not to have too much wire drawing of steam; but the disadvantages of large wheels are too great nowadays. There would be an excessive increase in the weight of the locomotives and in the weight not carried on springs, and it would be necessary, as in the old locomotives, to reduce the diameter of the boilers. The disadvantages of great angular speeds is counteracted by giving large cross sections to the steam passages, particularly by using piston valves. On the other hand, with locomotives having six or eight coupled wheels, very small diameters are not used; the diameter is hardly ever less than 4 ft. 7⅛ ins.

D. Materials.—The tendency is to use metals of good commercial quality; the use of special qualities, such as nickel steel, is very exceptional and does not appear to be extending. The applications of steel castings are becoming more and more numerous and varied.

E. Boilers.—A grate area of 32.29 sq. ft., with a heating surface of 75 to 80 times the size, is obtained by the usual construction, with narrow firebox. It appears to be difficult to obtain a much larger grate area on this plan, and this leads to the use of fireboxes extending over the wheels. The large wheels of high-speed locomotives must then be below the barrel of the boiler; this can be done in the case of the Atlantic type. In Europe, several applications of these extended fireboxes now begin to be seen, and it is probable they will increase. For a long time hesitation was shown in placing the grate above the axle, particularly in England; now that position of the grate is generally accepted. No doubt the same will happen with regard to the extension of the firebox above the wheels.

Very high pressures, 200 to 228 lbs. per sq. in., are used at present, particularly with compounds. They necessarily involve an increased cost of maintenance of the boilers. The Serve ribbed tubes are very generally used, particularly in France; they are useful by making it possible to have a larger heating surface with a boiler of given size. The tubes must be cleaned out frequently and with care.

F. Compound System.—As a general rule, it is well established that the compound system results either in a certain economy of fuel for the same power, or more frequently in an increased power for the same fuel consumption. In some few cases these advantages have not been realized; this may depend on the particular use made of the locomotives or to some defects in the application of the system. The use of four separate cylinders, acting by twos on cranks placed at 180° to each other, makes it possible to obtain greater power without fatiguing the mechanism too much; this arrangement balances the reciprocating masses without producing vertical disturbances. As far as possible the cylinders must act on two different axles, but these are coupled up. It is advisable that each system should have a valve gear of its own, and that it should be possible to operate independently the reversing shafts belonging to the two groups of cylinders (high pressure and low pressure).

G. Valve Gear.—No mechanism has succeeded in replacing the valve gear consisting of a slide valve and link motion. The link motions most generally used are Stephenson's and Walschaerts'. Valve gear without eccentrics has the disadvantage of being disturbed by vertical displacement of the axles. The only modifications of these old systems at all common is the replacement of flat slide valves by piston valves, which reduce friction, and consequently wear, and make it possible to arrange larger passages for the steam. On the other hand, a piston valve may leak; it makes it absolutely necessary to have a valve for admitting air to the valve chest for running with regulator closed, and it is advisable to fit relief valves on the cylinder ends.

H. Motion.—Tail rods are to be recommended as soon as the diameter of the cylinders attains or exceeds 19 21-32 ins. The lubrication of the slide valves and pistons is ensured in a continuous manner by lubricator pumps or by sight-feed lubricators.

I. Power of Locomotives.—With the present limits of weight admitted on the main European systems, locomotives can be built, thanks to the use of high pressures and the compound system, giving 1,480 to 1,973 I. HP.

J. Locomotives for High Speed Trains.—For heavily loaded high-speed trains, locomotives of the Atlantic type or locomotives with six large coupled wheels are used. The choice between the two types depends on the nature of the service, on the profile of the lines, and also on the maximum wheel load allowed.

K. Locomotives for General Purposes.—The locomotive with six coupled wheels and truck, the wheels having a diameter of 4 ft. 11 ins. to 5 ft. 10⅞ ins., is eminently suitable for a passenger train service, and the same locomotive can also haul freight trains satisfactorily.

L. Locomotives for Heavy Goods Trains.—For heavy goods trains there is a return to locomotives with eight coupled wheels, by preference with a leading pair of carrying wheels. These locomotives can exercise tractive efforts of more than 22,000 lbs.; they are limited by the strength of the couplings used in Europe.

M. Tank Locomotives.—A very fair amount of attention is being paid to the design of tank locomotives with six or even eight coupled wheels, either for suburban train services, where very quick starting is necessary, or for long runs. An axle or a truck is added either at one end, or at both, according to the nature of the service. Having two trucks, however, results in very long and very heavy locomotives. For the convenience of the service, these locomotives have long footplates for the crew and carry large quantities of water and particularly of fuel, at least as much as is carried in the small separate tenders which are still in use.

N. Locomotives with Flexible Wheelbase.—The only type of powerful locomotive with its whole weight adhesive and arranged to run over specially sharp curves, which is largely used, is the Mallet type. However, most railways content themselves with locomotives of the ordinary type, without flexible wheelbase.

O. General Remarks.—The railway industry does not escape a law which nearly all industries are subject to, owing to the rapid progress made in engineering, of almost continuously modifying its stock. As soon as new locomotives have been designed, superior to those used previously, one is tempted to think that to some extent finality has been reached, or at least that during a sufficiently long period it will be possible to do without any new designs. It appears very tempting to keep for a long time to standard types, which are cheaper to build and easier to maintain, but progress, which does not stop, hardly allows definite types to be determined in this way.

Thus on European railways we find locomotives developing 1,480 I. HP., or more, but the continual increase in train weights and train speeds makes it necessary already to look for still more powerful locomotives, if not for actually existing needs, then at least for the needs of the immediate future. The old equipment, however, is not to be given up entirely, and the variety of existing railway service makes it possible to utilize the older locomotives.

DESIGN AND CONSTRUCTION OF HIGH BRIDGE PIERS OF REINFORCED CONCRETE.

By Wm. M. Torrance,* M. W. S. E.

Early in 1903 it had been definitely decided by the officials of the Illinois Central Railroad Co. to reconstruct their bridge across the Tennessee River about twenty miles above Paducah, Ky., on the Louisville Division of the road. The Louisville Division is a single-track line from Cairo, Ill., to Louisville, Ky., carrying an extraordinarily heavy traffic for a single-track line, and it was desired to put into service there large No. 651 type locomotives instead of their No. 1 type, which are the heaviest locomotives now allowed on that line. The Tennessee River bridge was by far the largest and most important piece of reconstruction required by this change, the old bridge being strong enough for no heavier engines than those now used on it. The present line near the bridge has so much bad curvature that it was decided in the reconstruction to go up stream about 2,500 ft. to obtain a new line with less curvature.

The writer was engaged as Resident Engineer to take charge at the site of the reconstruction of this bridge in April, 1903, and began his duties May 5, taking charge of a surveying party getting notes of topography, float lines and soundings at 13-ft. and 24-ft. stages, the stages on May 6 and June 10, respectively. The drawings based on this work were submitted to the War Department for approval of the reconstruction, which approval was granted in August or September, 1903.

Meanwhile borings were being made to determine the nature of the foundations of the proposed piers. In general, these borings showed that there was a hard gravel bottom of considerable depth over hard, solid, flint rock, and it was decided from the nature of these borings and from the driving of a small test pile that it would not be necessary to go down to the rock with pneumatic or other deep foundations, but that piles driven to a penetration of 15 ft. or so would easily sustain a safe load of 40 tons per pile, or that the gravel bottom, stiffened and solidified by driving piles to that penetration, would easily sustain 5 tons per sq. ft. The writer was called upon to design the piers on that basis.

Large concrete construction had been the practice of the I. C. R. R. for a number of years, and if was decided to use concrete for these piers instead of stone masonry or any combination of stone masonry and concrete. Fig. 1 shows a profile of the crossing, and Figs. 2, 3 and 4 show typical construction plans for the piers.

These piers were designed to sustain, besides their own weight and that of the superstructure of a double-track bridge and its train loads, a tractive force equal to two-tenths of the double-track train loads applied longitudinally to the rail, and a wind load against the exposed surfaces of the bridge and train equal to 150 lbs. per lin. ft. applied in the plane of each chord, and 300 lbs. per lin. ft. (against the side of the moving train) applied 7 ft. above the rail.

Below are given the calculations incidental to the design for Piers 5 and 6, which support 300-ft. spans, one expansion end and one fixed end resting on each pier. The other piers are in all cases subject to less severe conditions. Pier 7 is to carry the fixed end of a 150-ft. span and the expansion end of a 300-ft. span, so that it would receive tractive force for 150 ft. of train load only and would have considerably less actual weight and wind load to support than Pier 5 or 6. Pier 2 is to carry the fixed end of a 150-ft. span and a swinging end of the 450-ft. draw span, which renders its loads slightly less than those on Pier 7. The calculations for Pier 7 were made in the same manner as those shown below for Piers 5

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6, and the resulting design was used for Pier 2 also. The loading on Pier 4 is not quite as great as that on Pier 5 or 6, and the design of the latter was used for Pier 4 also. It was found necessary, however, to make the distance from rail to top of pier greater in the case of Piers 2 and 4 than for Piers 5, 6 and 7, in order to allow room for locking devices, etc., at ends of draw span. Shore Piers 1 and 8 were designed in precisely the same manner, each to carry the expansion end of a 150-ft. span, and also the fixed

ft. diameter. The circular center line of the 8-ft. thick wall which comprises the shaft of the pier is also 38 ft. in diameter, which avoids eccentric stresses in the pier and ensures a good distribution of load over the entire base.

Both superstructure and substructure of the entire bridge are designed for double track, though superstructure for but a single track will be built at present. All parts are designed to take a ballast floor (instead of the open floor now being provided), should it ever be desired. The

downstream end. There is an extremely heavy load across the middle, which avoids tension at the top. As the plan shows, the pier is symmetrical about its center line in each direction.

The top of footing is made 13 ins. larger all around than the bottom of the shaft of the pier in order to facilitate construction—making a bench for holding the concrete forms and leaving space for final correction of survey lines. The footing course was designed somewhat like the frustum of a pyramid, with the corners rounded to conoidal

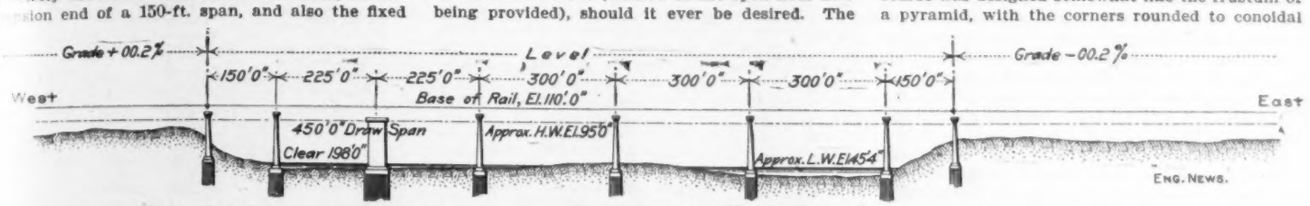


FIG. 1. PROFILE OF NEW CROSSING OF TENNESSEE RIVER AT GILBERTSVILLE, KY.; ILLINOIS CENTRAL R. R.

end of an additional 150-ft. span if the creosoted pile and timber trestle of approaches should ever be rebuilt with steel on concrete piers.

Pier 3, the center pier of the draw span, was designed as shown in Fig. 4, with a hollow interior space of about 1,000 cu. yds., to save expense and to save weight on foundation, thereby allowing a smaller foundation area than possible if a solid pier had been determined on. This hollow space is 30 ft. in diameter and is domed at the top. The load is uniformly distributed on the base by an inverted dome, as shown. The calculations for determining the size of foundation and number and spacing of piles were made similarly to those shown below for Piers 5 and 6, the pier taking the total dead weight of the draw span and its proper proportion of the live and wind

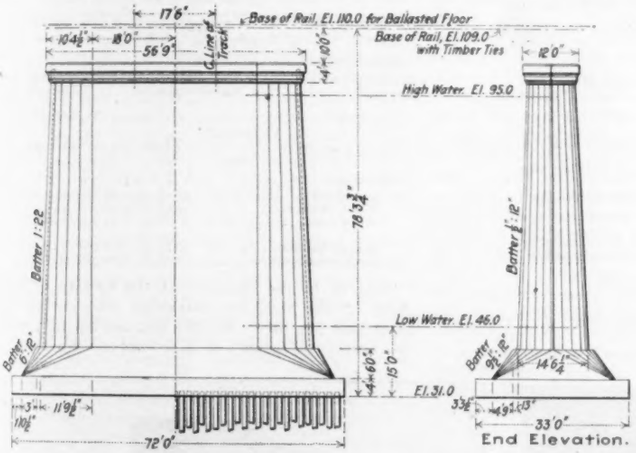
draw span is made a regular double-track span, with trusses 35 ft. on centers, for tracks 17 ft. 6 ins. c. to c. The superstructure of the remainder of the bridge is a three-truss scheme; at present only one outside truss and the heavier truss (future middle truss) are built. The piers are designed with this heavier middle truss on their center line, so that when desired to double-track the bridge it will be necessary only to add a single outside truss in each span and the floor system for a single track, the piers being all ready to receive it. This additional steel work can, of course, be ordered from the detail plans already made.

DESIGN FOR PIERS 5 AND 6.

FORM OF PIER.—It was considered economical and best to make the form of the nose of the

form, for the further purpose of preventing eddies and cross currents. This footing course has heavy batter on its sides to distribute the load well out on the foundation course.

The foundation course was designed sufficiently large, and sufficient piles were provided, to carry all loads inside the unit loadings mentioned above. In actual construction this foundation course was made 2 ft. wider all around than the designs and drawings called for, and an additional row of piles was driven on all four sides. This occurred on account of the cofferdam construction. These additional piles were not sawed off at the plan height of cut-off of the other piles, but were left standing and were used as braces for the Wakefield sheet piling. Twelve-inch timbers were bolted on the outside of this row of piles



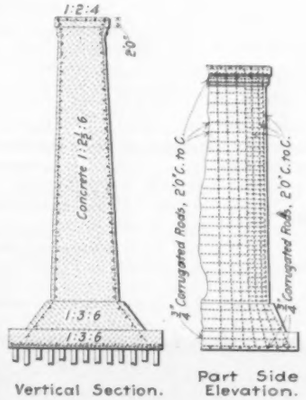
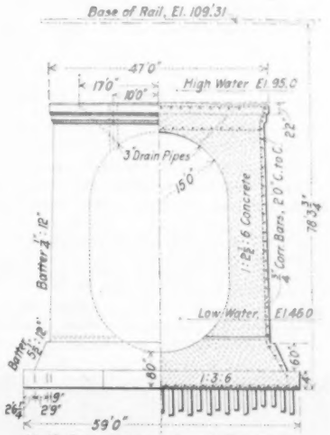


Fig. 3. Reinforcement of Piers of Gilbertsville Bridge.



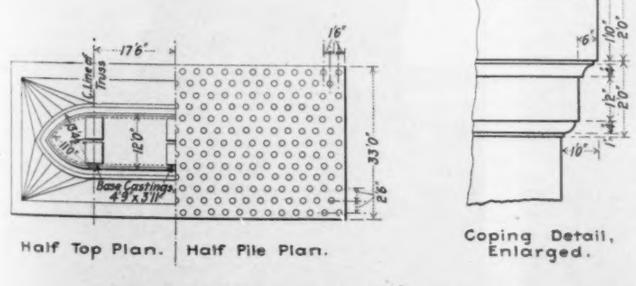


FIG. 2. PLAN AND ELEVATIONS OF RIVER PIER 5, GILBERTSVILLE BRIDGE.

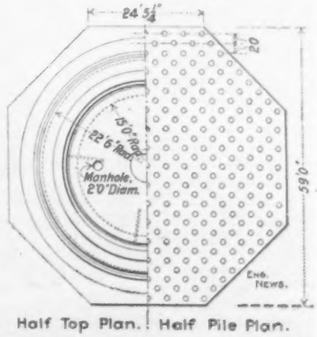


Fig. 4. Plan, Elevation and Section of Swing-Span Center Pier of Gilbertsville Bridge.

loads, as well as the total tractive force for 450 lin. ft. of train loads. The lever arm for moment at foundation in this case was measured from top of rail, instead of from center of end pin, as in the case of the other piers. The draw span is rim bearing. The entire dead and live load from the trusses is carried by the drum, which rests on coned wheels bearing on a cast-iron track of 38

pier segmental, as shown in Fig. 2, with an angle of about 90° at the nose. This form of pier will turn driftwood or other floating material (there is seldom much ice in the Tennessee River) better than a semicircular construction, and the shoes of the outside trusses can rest well out on the ends. It will also turn water without making cross currents, and will not tend to make eddies at the

and 10-in. Wakefield piling was driven outside of that. The entire space inside the sheet-piling was then used as area for foundation course. This made the foundations much stronger than planned and gave the best of chance for correcting possible small survey errors.

As the base plates of the 300-ft. trusses are 3 ft. 11 in. by 4 ft. 9 in., with 6 ins. between ends, the required width of pier under coping was 10 ft. The coping is made 4 ft. in thickness and 12 ft. in width at the top, making an offset of 12 ins. all around, which is relieved by ornamental molding, as shown in the drawings and in the view, Fig. 4, which shows the top of one of the shore piers in the foreground. It was decided to make the shaft of the pier extend down to 5 ft. below low water, and to have the bottom of the foundation 15 ft. below low water for all the river piers in order to be well below possible wash from the current of the river in all cases. The bottom of foundation course of the Shore Piers 1 and 8 was left at 5 ft. below low water, that being deemed sufficiently low in their case.

CALCULATIONS FOR DESIGNS, PIERS 5 AND 6.—The calculations given below are the final ones. Of course there were many preliminary calculations, not given here, which were made to determine by cut-and-try methods the proper relations between size of foundations, number and spacing of foundation piles, etc., in order to have a minimum yardage of masonry and keep inside the limits mentioned for safe loading.

Yardage of concrete:

Upper 2 ft. of coping, 1:2:4 concrete. Area in plan, 600 sq. ft.; volume.....	45 cu. yds.
Lower 2 ft. of coping, 1:2½:6 concrete. Area in plan, 556 sq. ft.; volume.....	41 cu. yds.
Shaft of pier, 1:2½:6 concrete. Top area, 490.5 sq. ft.; bottom area, 786.6 sq. ft.; medium area, 631.1 sq. ft.; volume by prismoidal formula (for height 56.86 ft.).....	1,335 cu. yds.
Footing course, 1:3:6 concrete. Top area, 926.5 sq. ft.; bottom area, 1,801.8 sq. ft.; medium area, 1,321.9 sq. ft.; volume by prismoidal formula (for height of 6 ft.).....	298 cu. yds.
Foundation course, 1:3:6 concrete. Volume, $4 \times 72 \times 33 \div 27 =$	352 cu. yds.
Summary:	
1:2:4 concrete in coping.... 45 cu. yds.	
1:2½:6 concrete in coping and shaft .....1,376 cu. yds.	
1:3:6 concrete in footing and foundation ..... 650 cu. yds.	
Total	2,071 cu. yds.
Weight of pier, at 155 lbs. per cu. ft., $2,071 \times 27 \times 155 =$	8,667,000 lbs
Dead load, three trusses with ballast floor, $9,126 \times 300 =$	2,738,000 lbs.
Live load from 300 ft. of double-track train loads, $5,000 \times 2 \times 300 =$	3,000,000 lbs.
Total gravity load on foundation.....	14,405,000 lbs.

The tractive force on the bridge is taken at two-tenths of the live load, as already stated; for each pier in question this is

Tractive force = $3,000,000 \times 0.2 = 600,000$ lbs.

Considering that this force acts in line of the lower chord pins (the trusses and floor system take care of it down to that level), we have,

Maximum tractive moment at foundation, in direction of tracks = $600,000 \times 72.35 = 43,410,000$ ft.-lbs.

It will be noticed that the tractive force is calculated on the full double-track load, which provides for its being called into play from both tracks *in the same direction* simultaneously.

Considering wind loads, as already specified, against the side of the bridge, we have

Maximum wind moment at foundation (at right angles to tracks):

$150 \times 300 \times 107 = 4,815,000$ ft.-lbs.
$150 \times 300 \times 73 = 3,285,000$ ft.-lbs.
$300 \times 300 \times 84 = 7,560,000$ ft.-lbs.

Total wind moment 15,660,000 ft.-lbs.

Thus the maximum forces acting on the bottom of the foundation course of the pier are such as to give a direct load of 14,405,000 lbs., a moment in direction of tracks of 43,410,000 ft.-lbs., and a moment at right angles to tracks of 15,660,000 ft.-lbs.

Our maximum unit loading being 40 tons per pile or 5 tons per sq. ft. (or, we might say, 20 tons per pile plus 2.5 tons per sq. ft.) it seemed best to space the piles in "hexagonal" arrangement instead of driving piles at the corners of squares of length or side equal to minimum spacing. By this method of spacing with distance center to center of piles 2 ft. 11 ins. we get approximately 1 pile in each 7.5 sq. ft. of foundation area, whereas if we spaced them the same distance apart in square scheme there would be one pile per 8.5 sq. ft.

The following figures of unit loading are computed: (1) Considering the earth to take all the load, and (2) considering the piles to take all the load:

Direct load on base,

per sq. ft..... $\frac{14,405,000}{72 \times 33} = 60,631$ lbs. $= 3.03$ tons.

per pile ..... $\frac{14,405,000}{306} = 470,751$ lbs. $= 23.54$ tons.

Max. and min. tractive-force loading on base, per sq. ft.

$$= \pm \frac{43,410,000 \times 16.5}{\text{Transverse mom. of inertia of area of base in biquadratic feet.}}$$

$$= \pm \frac{43,410,000 \times 16.5}{\frac{72 \times 33^3}{12}} \quad (= 215622)$$

$= \pm 3320$ lbs. $= \pm 1.66$ tons per sq. ft.

Max. and min. tractive-force loading on base, per pile

$$= \pm \frac{43,410,000 \times 15}{\left(\text{Transverse mom. of inertia of pile tops in units of sq. ft.} \times \text{number of piles.}\right)}$$

$$= \pm \frac{43,410,000 \times 15}{2\{24(15^2 + 10^2 + 5^2) + 23\ (12.5^2 + 7.5^2 + 2.5^2)\}}$$

$= \pm 24240$ lbs. $= \pm 12.12$ tons per pile.

Max. and min. wind loading on base, per sq. ft.

$$= \pm \frac{15,660,000 \times 36}{\left(\text{Longitudinal mom. of inertia of area of base in biquadratic feet.}\right)}$$

$$= \pm \frac{15,660,000 \times 36}{\frac{33 \times 72^3}{12}} \quad (= 1,026,432)$$

$= \pm 550$ lbs. $= \pm 0.28$ tons per sq. ft.

Max. and min. wind loading on base, per pile.

$$= \pm \frac{15,660,000 \times 34.5}{\left(\text{Longitudinal mom. of inertia of pile tops in units of sq. ft.} \times \text{number of piles.}\right)}$$

$$= \pm \frac{15,660,000 \times 34.5}{2\{7(34.5^2 + 31.5^2 + \ldots .1.5^2) + 6(33^2 + 30^2 \ldots 3^2)\}}$$

$= \pm 4250$ lbs. $= \pm 2.13$ tons per pile.

Summary of unit loading on base of foundation.

	Tons per sq. ft.		Tons per pile.
Direct load.....	+ 3.03	or	+ 23.54
Tractive load.....	± 1.66	or	± 12.12
Wind load.....	± 0.28	or	± 2.13
Maximum load.....	+ 4.97	or	+ 37.79
Minimum load.....	+ 1.09	or	+ 9.29
Average load.....	+ 3.03	or	+ 23.54

Or we might write it

Direct load.....	+ 1.52	plus	+ 11.77
Tractive load.....	± 0.83	plus	± 6.06
Wind load.....	± 0.14	plus	± 1.07
Maximum load.....	+ 2.49	plus	+ 18.90
Minimum load.....	+ 0.55	plus	+ 4.64
Average load.....	+ 1.52	plus	+ 11.77

TEST FOR STABILITY OF PIER AT BOTTOM OF SHAFT OF PIER.

Tractive moment at bottom of shaft of pier:

$= 600,000 \times 62.35 = 37,410,000$ ft. lbs.

Tractive stress per sq. ft.:

$$= \pm \frac{37,410,000 \times 7.375}{\left(\text{Transverse mom. of inertia of area of bottom of shaft in biquadratic ft.}\right)}$$

$$= \pm \frac{37,410,000 \times 7.375}{13,627}$$

$= \pm 20,250$ lbs. $= \pm 10.12$ tons.

Wind moment at bottom of shaft of pier:

$150 \times 300 \times 97 = 4,365,000$ ft. lbs.
$150 \times 300 \times 63 = 2,835,000$ "
$300 \times 300 \times 74 = 6,660,000$ "

Total..... 13,860,000 ft. lbs.

Wind stress per sq. ft. where tractive stress is a maximum.

$$= \frac{\pm 13,860,000 \times 18}{\left(\text{Longitudinal mom. of inertia of area of bottom of shaft in biquadratic ft.}\right)}$$

$$= \pm \frac{13,860,000 \times 18}{192,000}$$

$= \pm 1300$ lbs. $= \pm 0.65$ tons.

Direct (gravity) load per sq. ft.

Masonry weight, $1421 \times 155 \times 27$.....	5,950,000 lbs.
Live and dead load from superstructure....	5,738,000 lbs.
Total.....	11,688,000 lbs.

Load per sq. ft. $= \frac{11,688,000}{786.6} = 14,860$ lbs. $= 7.43$ tons.

Summary:

Direct load.....	+ 7.43 tons per sq. ft.
Tractive load.....	± 10.12 tons per sq. ft.
Wind load.....	± 0.65 tons per sq. ft.
Maximum load.....	+ 18.20 tons per sq. ft.
Minimum load.....	− 3.34 tons per sq. ft.

That is, in the concrete at the bottom of the shaft of the pier, the maximum compression is 18.20 tons per sq. ft. (or 252 lbs. per sq. in.), and the maximum tension is 3.34 tons per sq. ft. (or

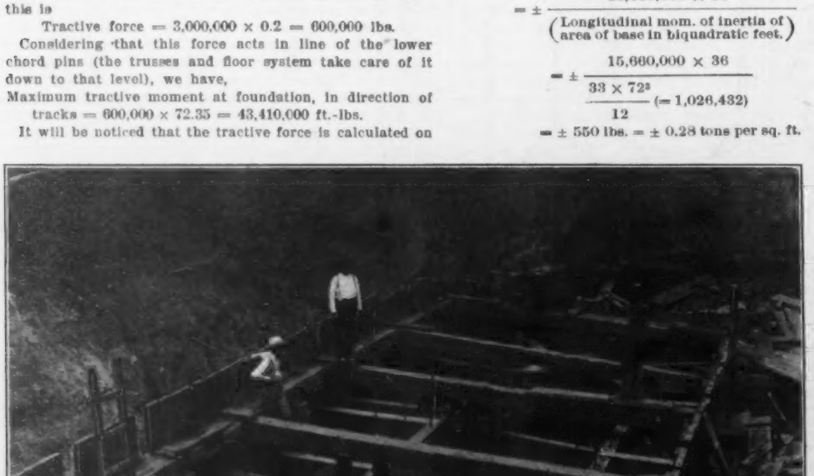


FIG. 5. PIER 8, GILBERTSVILLE BRIDGE, UNDER CONSTRUCTION, SHOWING METHOD OF SUPPORTING REINFORCING RODS.

FIG. 6. PIER 8, GILBERTSVILLE BRIDGE, NEARLY COMPLETED.

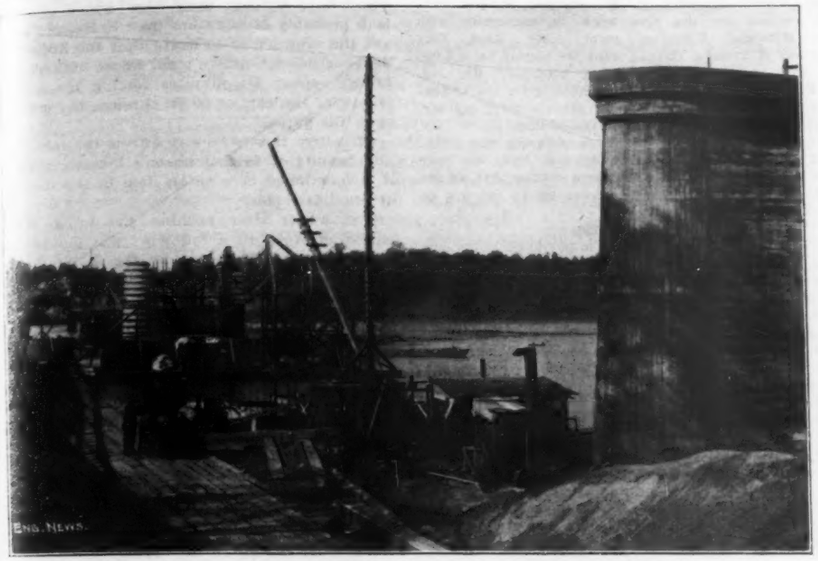


FIG. 7. PIER 8, GILBERTSVILLE BRIDGE, COMPLETED.

46 lbs. per sq. in.). A great advantage of using concrete instead of block stone masonry is that the concrete is much more capable of taking care of this tension than any stone masonry would be. To still further insure a monolithic action in the pier, however, it was decided to gridiron the entire surface with corrugated bars ("Johnson" bars of the St. Louis Expanded Metal Fireproofing Co.). These bars were placed 6 ins. beneath the surface on the sides and top, and also in a criss-cross near the bottom, the effect being to have a bar on every one of lines dividing the whole surfase into 2 x 2 ft. squares. (See Figs. 3 and 4.)

NOTES ON CONSTRUCTION.—Actual construction work on the Tennessee River Bridge Improvement did not begin until May 9, 1904, when ground was first broken on the grading of the approaches. Excavation was begun for the shore piers 1 and 8 on May 24, 1904, the river being at 6 ft. stage.

Specifications for the substructure work of the bridge had been presented to several large contracting companies in March and bids had been received on the "unit price" basis therein asked for from these companies in April. It was decided, however, to have the work done by "force account" (percentage on the total cost of labor and material entering the work), it being thought that economy would result to the railroad company by that method. The Bates & Rogers Construction Co., of Chicago, Ill., was invited to do the work on that basis. This company took the contract on the basis offered.

Nearly all the laborers employed were obtained from Chicago or St. Louis, and were boarded in a camp run by the contractor independently of the contract.

Figs. 5, 6 and 7 show progress on the construction of Pier 8, the shore pier on the east bank of the river. This was the first pier worked on, and the first pier finished. Fig. 5 shows Pier 8 after concreting had begun; it shows plainly the lines of the corrugated bars as used. The nearly vertical lines are ⅞-in. bars. At about the elevation of pile cut-off, 12 ins. above the bottom of concrete, a criss-cross of ¾-in. bars spaced 2 ft. apart in each direction was placed and the nearly vertical bars started from that elevation, being bent at the top of the footing course so as to be 6-ins. inside the surface of the shaft of the pier, and to have all the bars continuous at the bend, where possible tension on account of tractive force on the track above is a maximum. At intervals of 2 ft., lines of ¾-in. bars were placed, extending around the pier, being tied to the vertical bars at each intersection with small wire to secure it to place until concreted. An additional bar was introduced half way between these lines in each space extending around the curved ends only.

The splicing of the bars was governed by the following specification:

Joints in corrugated bar work shall be lapped at least 18 ins. They shall be tied with at least two turns of No. 16 galvanized wire. Bars shall be held in place by similar tying at intersections of horizontal and vertical lines. Joints in adjacent lines shall be not less than 5 ft. apart.

Fig. 6 shows Pier 8 nearly completed. This shows the use of the 10-in. I-beam extending up the nose of the pier, at each end, serving the double purpose of protecting the concrete from breaking off at the otherwise sharp edges at the ends and to strengthen the pier. This plate also shows a force of men back-filling around the pier. In this picture is also seen the construction track which was laid along the edge of the right-of-way on the surface of the river-bottom ground from the railroad yard at Gravel Switch Station, the eastern end of the improvement, and extending out into the river on pile trestle, where it served as unloading track for construction material to barges. Fig. 7 shows the pier completed. This view also shows construction work well under way on the other piers. The high derrick in the foreground is used to deliver concrete from the narrow gage track running from a Smith Mixer installed just east of Pier 8 where it was also used to mix concrete for that pier, to Pier 7, which, at the time this view was taken, is having its bottom sealed. For this purpose, concrete is dumped under water from bottom dumping buckets which are lowered to place before being dumped. This derrick is set high enough to deliver concrete to the top of the pier. At Pier 6 is shown a mixing barge on which a Smith Mixer and two derricks are mounted, the high one being used to deliver from the mixer to the pier, the other to serve the mixer from scows laden with concrete ingredients. At Pier 5 a somewhat similar mixing barge was being used. Work was progressing at this time also at the other piers farther west, Pier 1 being practically finished. The river was at this time at 1 ft. below "Low Water," shown on plans, which was the lowest previously recorded low water.

The general plan of work for constructing the river piers was as follows: 1. To dredge the area to be occupied by the pier foundation with good slope all around in open dredging to depth as low or lower than the plan elevation for bottom of concrete. 2. To drive the foundation piles in the bottom of the area so dredged. 3. To saw off the piles at proper elevation below water with circular saw. 4. To drive a row of piles around the foundation piles and construct outside of them the cofferdam of Wakefield sheet piling (each leaf of which was made up of an inside or middle piece of Southern pine, 4 x 12 ins., and two outside pieces, 3 x 12 ins., bolted together in lengths sufficient to allow work, if necessary, at 15-ft. stage of river). This Wakefield was shod with sheet steel in order to allow it to be driven to at least 3-ft. penetration without brooming it all out of shape. 5. To deposit concrete under water until top of concrete is up to one or two feet above pile cut-off, and there is reasonable assurance that bottom is sealed. 6. To pump out the cofferdam and finish the concreting of the foundation course out to the sheet piling. From this elevation forms are built, the reinforcing bars placed and concreting finished up to above water level when pumping is stopped and concreting of pier carried on to the top.

Not the least interesting part of the engineering work was the laying out of the location for the pier foundations and piers, the distances being, of course, much too great for chaining, and requiring an elaborate system of triangulation lines across the river and cross lines at pier centers. In this case one of the most serviceable of these triangulation lines was a line on the guard rail of the old bridge, points on which were so located that, by turning a certain angle (nearly 90°) from same, lines would be given intersecting the new center line at right angles at the various pier center lines of the new bridge. Lines parallel with these and at proper distances away could also be thrown out to give the side lines of the dredging area and of the pier foundation area in which to locate the foundation piles and cofferdams. By the use of a second instrument placed simultaneously on lines parallel with and at proper distance from the new center line, the corners of these areas could be located with greater dispatch than otherwise.

The piles used in the pier foundations were ordered on I. C. R. R. standard specifications for second-class piles and were of mixed oak, sycamore, gum, and hickory. Many of them were cut in the immediate vicinity of the site and were hauled there on wagons or towed on barges or in rafts from landings up or down river. The remainder were shipped in by rail from various points in Illinois, Kentucky, and Tennessee. In order to expedite work, pile driving was carried on night and day, the one steam-hammer driving practically all the piles for the river piers. These piles were from 38 ft. to 46 ft. in length and were driven to an average penetration of about 17 ft. in the hard gravel river bottom. The steam-hammer weighed 16,000 lbs., the piston weighing 5,500 lbs. and having a drop of 3 ft. Six or eight per cent. of the piles broke before reaching much penetration, and were replaced by others. If the second pile broke in any case on account of hardness of bottom, the attempt was abandoned in that spot.

Nearly all the foundation piles were driven practically to refusal, the last inch of penetration sometimes requiring several hundred blows and many of the piles, on account of this, being left at as small as 10 ft. penetration. No attempt was made to follow the piles below water level, though many of them received more than the average penetration and were driven that far. The weaker piles were shod with cast-iron shoes, and, where the driving was particularly hard, all the piles were so protected. Perhaps 30% in all were shod.

The erection of the superstructure is being done by the Kelly-Atkinson Construction Co., of Chicago. It is expected that the new bridge will be ready for traffic within two or three weeks. From May 4, 1903, until Oct. 1, 1904, the writer was Resident Engineer of the Improvement. Since that date Mr. H. H. Hadsall has held that position. The work has been under the immediate supervision of Mr. F. H. Bainbridge.* Asst. Engr. of Bridges, later Engineer of Bridges of the Road.

A SAFETY NET is said to have been used in the erection of the great arch bridge over the Zambesi Falls in South Africa, and to have been the means of saving several lives. The net was made of rope-mesh in the same manner as the nets used in circus acts under performers on the flying trapeze. As the bridge was erected as a cantilever by building out from each shore until the two halves of the arch met at the center, the net did not interfere at all with the handling of materials in construction.

*Mr. Bainbridge is now Prin. Asst. Engr. of the C. & N. W. Ry., Chicago, Ill.

SOME ADDITIONAL NOTES ON PIPE COATING.*

By F. W. Cappelen,† M. Am. Soc. C. E.

Since the construction of the 50-in. steel pipe lines for the Minneapolis water-works several separate reports on the conditions of said lines have been made to this society as well as to individuals. As, however, requests for information continue to arrive, the writer thinks it might be of general interest to present a condensed report covering the subject from its inception up to date.

During the winter 1896-97 it became the writer's duty to prepare specifications for about 65 miles of 50-in. riveted steel pipe. The troublesome feature was the coating. After several experiments and a great many tests having been made (see paper on tests of coating for steel water pipe by the writer read before the Am. W.-W. Assoc. at Denver, 1897). A coating called mineral rubber asphalt, from Utah, was selected.

The pipes were thoroughly cleaned, dried and then heated to about 300° F. and immersed in vertical tanks containing the coating heated to 300°. The pipes arrived in Minneapolis in excellent condition and the coating suffered very little in railroad transportation, and the hauling of an average of three miles on wagons to the ditch and in final handling and riveting. Abrased parts and field riveted joints were painted in the field with durable metal coating.

Some of the original test pipes coated in the early part of 1897 were exposed to the air for one year, then they were immersed in running city water for one year and thereafter they laid one year in one of the big sewers of Minneapolis. The pipes were examined after each treatment and in every case the mineral rubber showed up the best. The different coatings referred to were.

No. 1. Mineral rubber asphalt from Utah.

No. 2. Trinidad asphalt mixed with dead oil as used for the No. 42-in. steel pipe line in Duluth, Minn.

No. 3. California asphalt from Waldorf, Cal., mines.

No. 4. California asphalt from Waldorf, Cal., mines, mixed with 40% of maltha.

No. 5. Practically the so-called Angus Smith coating.

In May, 1900, the writer personally inspected the inside of the 50-in. lines in Minneapolis and found the coating just as good as new. Near one of the joints he found a lump of coating which was removed. The material was exactly as the original one, glossy and elastic.

In May, 1903, the writer examined the outside of the pipe line in several places, choosing points where the soil was of a different character, such as sand, clay and in one place swamp land. In all cases the coating was excellent. In 1904 connections with the steel lines were made with the new pumping station. The story is the same; the coating was as good as new, both inside and outside. A few days ago the writer again examined the inside; the result was the same. In one place the writer found a lump of coating material. The material was elastic enough so that a penknife could be inserted and stick, although the ice cold water was not yet all drained out of the pipe. The metal under the coating was perfect.

The writer found upon the last investigation by cleaning of a field joint that the coating of the top of a couple of rivets came off. This was the durable metal coating used in the field, and the writer would on a new job in the field use the hot mineral rubber coating, even if it should be necessary to heat the pipes, by applying waste dipped in kerosene and ignited. As there are at the present writing several feet of frost in the ground it was impossible to again examine the pipes from the outside.

Upon the writer's advice the city of Seattle, Wash., in 1899 used the mineral rubber coating for seven miles of 42-in. steel pipe. Mr. R. H. Thomson, City Engineer of Seattle, writes under date of April 4, 1905, that the coating is still bright and firm at any place where it has been examined.

The mineral asphalt rubber coating referred to was manufactured by a company which subsequently went out of existence. A new company was eventually formed which now manufactures the same coating. In 1903 this company requested the writer to make a report on the original coating, which he refused to do until he had examined the coating prepared by the new company. Samples were furnished and analysis made with the following results:‡

	Minneapolis coating— 1897.	1905.	New coating, 1903.
Petrolene (soluble in petroleum ether).....	75.71	68.1	65.31
Asphaltene (soluble in chloroform)	23.59	27.26	33.71
Total bitumen	99.30	95.36	99.02
Coke and organic matter	.49	3.42	.81
Ash (mineral matter)..	.21	1.23	.17
Total	100.00	100.00	100.00

The analysis of the coating as it is to-day on the inside of the pipe shows (see column two of Table.—Ed.).

The total bitumen of the other asphaltic coatings experimented with in 1897 were from 57% in the Trinidad to 83% in the California.

Mr. Morris Knowles, C. E., specified Mineral rubber coating for the pipe work in connection with the Pittsburg Filtration plant. Mr. Rust, City Engineer of Toronto, Canada, used the coating for a 5,000 ft. long steel conduit 6 ft. in diameter; Mr. Jas. H. Fuertes, C. E., New York, specified it for the Lynchburg, Va., works. Mr. Allen, of Atlantic City, and Mr. Maury, of Peoria, Ill., have used the coating.

Mr. T. A. Gillespie, of the T. A. Gillespie Co., Pittsburg and New York, wrote on April 3, 1905: We have been continuing the use of the same coating that we did with you in 1897. It is the best coating we can find so far.

A few words about other coatings:

In 1901 the writer had occasion to put in place the new 42-in. steel intake pipe line in Lake Superior for the city of Marquette, Mich. The pipe had already been bought by the water board of Marquette, and had been delivered when the writer was engaged. The Rochester Branch of the American Bridge Co. furnished the pipe. The shop-work was good, but the coating, whatever it may have been, was exceedingly bad. It peeled off everywhere and the pipes had to be scraped and painted with Smith's paint.

Mr. McGilvray, City Engineer of Duluth, Minn., writes under date of April 4, 1905: An examination of the steel pipe line made some years ago, showed the coating was in an excellent condition, after having been in use for four and one-half years.

The following letter is quoted in full, being of special interest, because in this case "Sabin" coating was used. Unless misinformed this pipe line was laid in 1896:

Copy.

Water-Works,
Office of the Superintendent,
Cambridge, Mass.

April 1, 1905.

Mr. F. W. Cappelen, C. E.,
610-611 Globe Building,
Minneapolis, Minn.,

Dear Sir:

In answer to yours of March 29, I would say that the coating of our 40-in. steel main was known as the Sabin coating. Its condition, when uncovered last year for repairs, was in some respects very good, but it is brittle and is easily knocked off by anything like contact with shovels, or any iron or steel tool used for cleaning; it does not seem to protect the iron or steel as well as we had hoped. I have had some considerable patches of it, possibly 4 ins. or 5 ins. long by 2 ins. wide, come off with the clay that laid up against the pipe, so that taken as a whole, although looking well when first uncovered, it does not answer the purpose as well as we had hoped it would.

Yours truly,
(Signed) C. E. BROOKS,
Superintendent.

RECOMMENDATION.—The author would recommend coating to be of a consistency as nearly as possible as the one used in Minneapolis. He would also use the same coating applied hot for field work, and insist on absolute cleaning of pipes by the use of sandblast before dipping.

*A paper read before the American Water-Works Association, West Baden, Ind., May, 1905; slightly condensed.

†Consulting Engineer, Minneapolis, Minn.

‡The second column has been added from a table given subsequently in the original paper.—Ed.

THE DULUTH FERRY BRIDGE IN OPERATION.

By K. C. E.

The "aerial" or suspended ferry bridge across the Duluth Ship Canal has now been in operation about five weeks, and so far has been a complete success; no trip of the car having been missed because of defect in general design, and only a single change in detail found necessary.

It was opened to the public March 27, having been previously tested with a load of scrap iron weighing about 67 tons. The next day it was decided by those in charge that the supports of the 9 ft. cable drums should have additional stiffness, and the service was discontinued until April 2, when regular trips were resumed, and have been continued regularly and successfully to date, except for three days, to paint the inside of the lower chords where the wheels run.

The power design has proved more than ample, which enables the car to move with scarcely any tremor, and faster than the designed speed. The net distance traversed by the car, as a reference to the files of the Engineering News will show, is 391 ft., and the usual time consumed in crossing ranges from 60 to 75 seconds, or an average speed of 3½ to 4½ miles per hour, including the starting and stopping. April 9 being Sunday and fair, a man was stationed on the car by the contractors to count the passengers on each trip. Between the hours of 12 noon and 7.15 p. m., 29,944 passengers were counted. The highest number on a single trip was 814.

This is noteworthy as to floor loads: the total available floor space on the car is 1,347 sq. ft., besides which is the seat room of 100 lin. ft. of 12-in. street car bench sittings. The equivalent net floor space, therefore, is nearly 1,400 sq. ft., and a crowd of 814 people, including ladies and small boys without their dogs, would indicate a load probably of not more than 75 lbs. per sq. ft.; yet the crowd was so dense that the Superintendent—a slender, active man, whose authority was known—spent 1¼ minutes forcing his way the length of the car, or 50 ft. through the crowd to open the gates.

Of course this is no way affects the more valuable results of Prof. Johnson's investigation, but it is mentioned here as an item in the test of practical loads.

Two weeks after opening the bridge to the public, on April 16, a fair wind was blowing and for a time was recorded by the U. S. Weather Bureau as 38 miles per hour. This at a pressure of 7 1-5 lbs. per sq. ft. gave a total pressure against the car, traveler and hangers of 4,300 lbs., and was sufficient to start the car and move it across with the wind as soon as unlatched, power being turned on only to set the electric brake on landing at the approach. At noon the wind was recorded at 32 miles an hour, which at 5 lbs. per sq. ft. gave a pressure of 3,000 lbs. This pressure was sufficient to keep the car going when started, power being used only for the first 50 ft., and to set the brake at landing. Adjustments made since have noticeably reduced the friction still further.

Winds broadside to the bridge have occurred several times with a recorded velocity of 55 and 60 miles per hour, with the bridge in operation, without producing any sway or other effect that could be discerned by the unaided eye, and as the high winds were at night, a transit could not be used. Wind, however, of 33 miles per hour velocity broadside caused a deflection in truss and hangers combined of 7-16 in., as determined by means of a transit.

The following general data concerning the bridge will bear repetition and save a reference to the files of Engineering News:

Clear span 393.75 ft.
Clear height above Lake Datum, 136 ft.
Clear height above avenue grade and canal pier promenade, 129 ft.
Depth of truss at center, 49 ft.
Width between trusses, 34 ft. c. to c.
Height of car floor above pier promenade, 9 ft.
Clearance of lowest portion of car above promenade, 6 ft. 1 inch.
Weight of hangers, traveler and car, 115,000 lbs.
Live load on car, 125,000 lbs.
Total weight of steel in bridge, 692¾ tons.
Type of truss, 9 panel, double Warren riveted.

The bridge was built by the Modern Steel Structural Co., of Waukesha, Wis., at a contract price of $100,000, including the design and plans, which were by C. A. P. Turner, M. Am. Soc. C. E., of Minneapolis.

The field painting is not yet completed at this date (May 11), but will be, doubtless, in about a week, when the bridge will be turned over to the city.

STEEL PASSENGER CARS were a feature of the Railway Appliances Exhibition at Washington. One of these was a suburban car for the electric service of the Long Island R. R.; and had both the framing and sheathing of steel. This was built by the American Car & Foundry Co. Another steel car for passenger train service was a mail car for the Erie Ry., built by the Standard Steel Car Co., and this also had steel sheathing. A very handsome private car built for Mr. H. E. Huntington, President of the Los Angeles & Pacific Electric Ry., was exhibited by the St. Louis Car Co., but while the entire framing is of steel (with plate girder sides), the exterior sheathing is of wood, and the decorative interior finish of course conceals all the framing. This car is 63 ft. long over the vestibuled ends, 9 ft. 6 ins. wide and 9 ft. 11 ins. high from the bottom of the underframing to the top of the roof. The sides are plate girders 3 ft. deep, with top and bottom flanges composed of a pair of channels, forming the side sills and belt rails respectively. There are 11 transverse I-beams, attached to the girders by angle braces and gusset plates, and at each end are four intermediate I-beam sills extending from the bolsters to the end sills. The bolsters are of steel plates, with cast steel fillers. The posts are steel T-bars resting on the top flanges of the side girders and supporting steel channel roof plates, to which are riveted the carlines of steel channels bent to shape for a wide monitor roof. To the steel frame are bolted wooden fillers for the attachment of the outside sheathing and interior finish. The car has observation rooms, kitchen, bedroom, toilet rooms, and every convenience, while the finish is very elaborate. It is mounted on four-wheel trucks with a 200-HP. Westinghouse motor to each axle, and its weight complete is about 50 tons.

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ADVERTISING RATES will be furnished upon application. "Want" and "For Sale" notices (especial rates) see pages 24-27. The pages for new "Want" "Proposal" and "For Sale" advertisements are held open until Wednesday noon.

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The recent frightful accident on the Pennsylvania Railroad through the explosion of a carload of dynamite has started public discussion over the question, how explosives may be transported with greater safety. It is not easy to answer such a question. As a matter of fact, the railways are now transporting to all parts of the country many thousands of tons of high explosives every year, and accidents in the course of transportation are extremely rare. Before any change is made in existing laws or regulations or customs, we should be entirely certain that any change will not lead toward dangers greater than those which it aims to avoid.

For example, various newspaper editors have proposed that the transportation of dynamite by rail should be prohibited altogether. But if this were done the result would be the establishment of hundreds of small dynamite factories all over the country, whose product would have to be distributed by wagon over country roads, passing through streets of towns, cities and villages. As the manufacture of dynamite is many times as dangerous as the handling of the finished explosive, the net result of such a change would surely be a multitude of accidental explosions in all parts of the country and a total annual loss of life and property by far greater than that which now occurs.

The same thing would be true in some degree of any general law or regulation so restricting the carriage of dynamite by rail as to make its transportation seriously difficult or expensive.

There is no doubt at all that railway men generally would gladly be rid of the responsibility of transporting explosives, and that they are taking a broad and correct view of their duties to the public as common carriers in accepting it for transportation under proper regulations.

It has been suggested that railways might transport dynamite only in special trains, to be run at times when the road is least busy with other trains and with especial care to keep the track clear. There may be merit in this proposal for trunk line railroads, where the amount of such freight shipped would justify the use of a special train at intervals of a week or more; but how about the great mileage of branch lines? If dynamite may only be carried in special trains to the towns along these lines, then the inevitable effect would be to greatly increase the amount of dynamite held in storage everywhere; and this again would manifestly be contrary to public safety.

The best general requirement that we can see for the safe transportation of high explosives is the requirement that all shipments shall be conspicuously labeled. Let every car in which more than so many pounds of dynamite is carried be placarded on both sides with a large colored label bearing the word "explosive." Such a label would be a useful warning to trainmen, yardmen and all concerned, to be particularly careful in handling such cars.

It appears that the recent accident was primarily due to the emergency application of air brakes on a very long train, causing shocks which derailed cars near the center of the train. Something might be said here concerning the extremes to which operating officials are tending in the movement of long trains, and the injuries to cars and draft gear and the frequent wrecks which are caused thereby. For our present purpose, however, it is sufficient to say that if dynamite cars were distinctly labeled, the operating officers would be more apt to send them forward in trains containing no more cars than could be moved with reasonable safety.

We do not believe that there is any need for legislation on this matter. The railway companies for their own protection are likely to take all reasonable precautions in the handling of dangerous explosives.

Doubtless the best solution to the whole question and the one which in the course of years will eventually be brought about will be the substitution of safety explosives in place of the explosives of the nitro-glycerine class, which have so long held the market. Many of these safety explosives have been invented and several are now in extensive commercial use. The tendency ought to be in the future toward their gradual substitution for the explosives of the nitro-glycerine class, just as these displaced nitro-glycerine itself in general use some thirty years ago.

The expected happened in Philadelphia last Thursday, when the select and common councils, each by an overwhelming majority, put through the ordinance extending the lease of the city gas works from the year 1927 to 1980. The press, the public and the mayor of the city had expressed themselves strongly against the extension, but after a slight delay and a farcical call for bids the programme secretly agreed upon was carried out mechanically. At the last moment a concession in rates was made, as very likely was planned from the start, but, in view of all the circumstances, the rate reductions are wofully inadequate.

By the lease extension the city heavily mortgages the future, and at an apparently ruinous interest charge, for the benefit of the present, puts its valuable property entirely beyond its control until 1980, and at the same time fixes the price of gas at $1 a thousand until 1911, and at 80 cents after 1956, with slight reductions from 90 cents between 1911 and 1956.

The $25,000,000 in cash payment for these privileges, besides being wofully inadequate, is really contributed by the gas consumers. The money, however, is to be used for a variety of public improvements, so the gas consumer is burdened to just that extent for the relief of the general taxpayer. The gross unfairness of this is manifest to anyone familiar with the elementary principles of taxation.

The farcical call for bids, which was not issued until councils and their managers thought something must be done to lessen public indignation over the lease extension, resulted in a complicated proposal which served no other purpose than a weak framework for excuses for extending the old lease. A few people may have honestly thought that the call for bids gave some promise of competition, but, under the circumstances, competition was out of the question.

In this particular case probably few were deceived by the competition fetish, but unfortunately it has deceived, and is still deceiving, the inhabitants of many cities. Some day, perhaps, at least a fair portion of the so-called intelligent classes will understand that competition cannot be called into existence where the basic principles of its existence are lacking.

It may be said in closing that Mayor Weaver has virtually promised to veto the gas extension ordinance, but that it is expected that his veto will be overridden. Whether or not the veto is effective will depend upon the public spirit displayed by the people of Philadelphia before the next meeting of city councils.

A case of great interest to contractors and other employers of labor has been recently decided by the United States Supreme Court. We refer to the case of Lochner vs. the State of New York, involving the validity of the New York statute prohibiting proprietors of bakeries from requiring or permitting employees to work more than ten hours a day. The decision rendered by the court is in part as follows:

> We think the limit of the police power has been reached and passed in this case. There is, in our judgment, no reasonable foundation for holding this to be necessary or appropriate as a health law to safeguard the public health or the health of the individuals who are following the trade of a baker. If this statute be valid, and if, therefore, a proper case is made out in which to deny the right of an individual, *sui juris*, as employer or employee, to make contracts for the labor of the latter under the protection of the provisions of the Federal Constitution, there would seem to be no length into which legislation of this nature might not go.
>
> We think that there can be no fair doubt that the trade of a baker in and of itself is not an unhealthy one to that degree which would authorize the Legislature to interfere with the right to labor and with the right of free contract on the part of the individual, either as employer or employee. It might be safely affirmed that almost all occupations more or less affect the health. There must be more than the mere fact of the possible existence of some small amount of unhealthiness to warrant legislative interference with liberty. In our large cities there are many buildings into which the sun penetrates for but a short time each day, and these buildings are occupied by people carrying on the business of bankers, brokers, lawyers, real estate and many other kinds of business, aided by many clerks, messengers and other employees. Upon the assumption of the validity of this act under review it is not possible to say that an act prohibiting lawyers' or bank clerks or others from contracting to labor for their employers more than eight hours a day would be invalid. It might be said that it is unhealthy to work more than that number of hours in an apartment lighted by artificial light during the working hours of the day.
>
> It is also urged, pursuing the same line of argument, that it is to the interest of the State that its population should be strong and robust, and therefore any legislation which may be said to tend to make people healthy must be valid as health laws, enacted under the police power. If this be a valid argument and a justification for this kind of legislation, it follows that the protection of the Federal Constitution from undue interference with liberty of person and freedom of contract is visionary wherever the law is sought to be justified as a valid exercise of the police power. The act is not within any fair meaning of the term a health law, but is an illegal interference with the rights of individuals, both employers and employees, to make contracts regarding labor upon such terms as they may think best, or which they may agree upon with the other parties to such contracts. Statutes of the nature of that under review, limiting the hours in which grown and intelligent men may labor to earn their living, are mere meddlesome interferences with the rights of the individual.
>
> It is manifest to us that the limitation of the hours of labor, as provided for in this section of the statute under which the indictment was found and the plaintiff in error convicted, has no such direct relation to and no such substantial effect upon the health of the employee as to justify us in regarding the section as really a health law. It seems to us that the real object and purpose were simply to regulate the hours of labor between the master and his employees (all being men, *sui juris*) in a private business, not dangerous in any degree to morals or in any real and substantial degree to the health of the employees. Under such circumstances the freedom of master and employee to contract with each other in relation to their employment and in defining the same cannot be prohibited or interfered with without violating the Federal Constitution.

Notwithstanding the wide reaching effect of this decision, it should be remembered that it does not bear upon the right of a State, for example, to limit the working hours of the employees of contractors who are doing work for the State; nor does it touch upon the right of a city, or a town, to set similar limitations upon its own contractors and employees. On the other hand, the decision

appears to settle once and for all the right of a State to dictate to a city, or to a town, or to a corporation, or to an individual, not working for the State, the maximum length of a day's work; for the Court declares any such dictation to be in violation of the Federal Constitution.

A very curious and unusual clause has been inserted in the advertisements to contractors calling for bids for work under the U. S. Reclamation Service. It reads as follows:

> The right is reserved to reject any or all bids, to accept one part and reject the other and to waive technical defects as the interest of the service may require.

It will be evident that under the above clause the Government will have the power to sort over the bids, and accept one contractor's bid for lumber, another's bid for masonry, another's for rock excavation, another's for cement, etc.

That such a procedure would be most unbusinesslike and most unusual, and that no contractor could afford to perform work under such conditions except at prices far beyond those usually charged, will be evident at a glance to every contractor and engineer. It seems a safe guess that the insertion of this clause must have been due to some one in the Department wholly ignorant of engineering work, since the engineers of the Reclamation Service must be fully aware of its injurious effect on the Government's interests. Indeed, a circular has been sent out by the Reclamation Service calling the attention of contractors to this clause in the advertisement and requesting them to prepare alternate bids, one giving the prices for each item, if the entire work is awarded to the bidder as a whole, and the other the prices for each item, if the contractor receives the award of that particular item alone.

Remembering that most of the Reclamation Service works are far distant from the centers where supplies and labor are gathered, and that a large part of the expense in performing a contract will be incurred in bringing the plant and force onto the ground, it is evident that few contractors will care to make any bid for performing separate items of these works.

SPECIFYING BY REFERENCE TO STANDARDS.

There are certain classes of work difficult to specify in words. One of the most familiar examples is excavation. To distinguish rock from hardpan, and hardpan from earth, by applying the tests prescribed in a specification, is often impossible. The different classes of masonry merge into one another much in the same manner. First-class under one engineer is second-class under another, even where the wording of the specifications is much the same. Timber work that is acceptable to one inspector is called "timber butchering" by another. We recall a large timber crib built for a breakwater, final payment on which was held up because the job had not been done in "workmanlike manner." In a word, there are many kinds of construction specified in such a way that the minds of the two parties to the contract never meet; nor is it always possible to change the wording of the specification so that the contractor will form a clear concept of what is wanted. The engineer may have a definite mental picture of the class of work that he wishes the contractor to do, but without intending to deceive, he may actually mislead the contractor.

Then, again, it frequently happens that the engineer in charge of the work at the time of the letting of the contract, resigns, and is succeeded by another man whose views are radically different. Is there no way of providing for such conditions in such a manner that the minds of both parties to a contract may meet in the beginning? We believe that in most cases there is a way of giving definiteness even to that indefinite word "workmanlike."

When an experienced engineer says "workmanlike," he has in mind some work previously done under his direction that has satisfied him. When he uses the word quicksand, he thinks of a substance that was excavated in such and such trenches. Now it should be his endeavor to picture these structures or substances in some manner intelligible to the contractor. Perhaps it can not be done in words; then there are left but two ways. The first consists in referring the contractor to some structure near at hand if possible, where the contractor may see the kind of work that the engineer calls "workmanlike," or "first class," or "acceptable." The second method consists in having exhibits or samples on file in the office as standards of what the specificaaions call for. Both of these methods have been used successfully, but not as frequently as they should be.

On the New York Barge Canal, for example, samples from all the borings and test pits are stored in little houses along the line of the work; and they are so numbered that the contractor may form some definite idea of the class of material to be encountered in different places. It would not be a difficult matter to select a line of these samples, and classify them, so that unit prices might be bid upon each class.

On some contracts involving a large amount of timber trestling the specification called for "workmanship equal to that on the highway trestle at——"

Fault may be found with this method of specifying by reference to standards, because, for example, only the exterior of the work may be in evidence. However, it is often possible to remove a portion of the old work so as to expose a section; and in building standards for exhibition sections can always be exposed.

Specifying by reference to standards has a distinct advantage of its own. Not all contractors are capable of interpreting the requirements of a specification, particularly when the work is of a class, or in a locality, new to them. But if they can see a sample of the work, there is less chance of their bidding either too low or too high.

Another advantage of providing a standard built in stone or wood, or metal, instead of words, arises from the fact that the very building of the standard may lead to economy in the design; for such building will call attention to the quality of local materials, and often disclose their unfitness under certain conditions, or their fitness under other conditions. Furthermore, such building of a standard should show the relative percentage of different materials required, and that in itself will frequently lead to changes in design (before the letting of the contract), and consequently to greater economy.

Finally there is the matter of law suits. A standard wrought in the materials actually to be used is definite—susceptible of but one meaning. A standard built of phrases is seldom free from defects of one kind or another. Often the defects are defects of omission. There has been failure to supply a few words relative to an important operation, or an essential material. Then, unless an amicable agreement can be reached, one or both parties to the contract may suffer a loss out of all proportion to the importance of the omission.

There is a growing belief in the efficacy of testing the site of proposed structures by making excavations, and where the work is large the test excavations may be large. We have a striking example of this practice on the Panama Canal, where a demonstration is being made not only of the character of the materials but of the maximum actual costs of excavation. When contracts are let for this great work, the prices will be far less than they otherwise would have been had no demonstration been made of the character of the work. This in fact is specifying by standards, carried one step farther than the mere exhibit of the materials.

In many cases where large numbers of piles are to be driven, the engineer would save much money for his clients were he to drive a sufficient number of piles to show the contractors not only the penetration, but the number of blows required to secure it.

Likewise, when rock is to be excavated on a large scale for masonry or for concrete, a few dollars spent in drilling and blasting to show the toughness of the rock, the necessary spacing of holes, and the size and shape of the blocks thrown down by the powder, would result in closer bidding and fairer prices. Strangely enough, though thousands of dollars have been spent upon surveys and studies of projects involving extensive use of stone, there has never been (so far as we know) such a demonstration by actual quarrying of the rock to be used. At least such demonstrations have not been made by the engineers for the work. Contractors have occasionally made such tests in a small way for their own information; but usually the time is so limited and the work to be examined is so great that contractors can not be expected to make their own tests—particularly when we consider that the chance any particular contractor has of securing the contract is but small. It rests, therefore, with the engineers to demonstrate what the rock is like—to specify by showing the material and its structure.

We may be told that the engineer runs great risks in making any attempt to give contractors a clear idea of the character of rock in this way suggested. For, should the engineer by chance select a part of the ledge that is not typical he may deceive the contractor far more than the contractor would deceive himself were no preliminary excavations made. To this objection there is a sufficient reply: In the northern half of this country the rock is seldom decayed to any great depth, due to the fact that ancient glaciers have wiped clean the strata and the igneous intrusions. In the South, below the glacier line, rock debris is heaped above the solid rock, often for hundreds of feet; so that a surface excavation in a ledge does not disclose the character of the ledge below. A knowledge of the principles of geology, and a geologic folio, should in any case enable the engineer to avoid any serious error in the vast majority of cases where attempt may be made to demonstrate the character of the rock by opening up a small section. Even where the nature of the rock strata varies within short distances, it takes but a moderate amount of knowledge and reasoning to avoid blundering. But, granting that a blunder does occur, and that the excavation made is not typical, still it can be given for what it is worth and for no more. The contract can be so drawn as to relieve the party of the first part from all responsibility as to the excavations and the samples obtained from the excavations; although, in the long run, it may be best not to attempt to escape such responsibility.

Specifying by reference to standards has its limitations, which we shall not attempt to discuss, it being our present purpose to call attention to a practice that has been noteworthy for the rarity of its application, even where its use would have been especially advantageous.

LETTERS TO THE EDITOR.

Reinforced Concrete for Structures Subject to Vibration.

Sir: I would like to know what the experience of the readers of the News has been in using reinforced concrete as a supporting structure for vibrating machinery or machinery subject to sudden impact, or reciprocating motion. Has experience shown that reinforced concrete beams and girders can be used for this kind of loading by properly reducing the unit stresses in a manner similar to that used for steel alone? Very truly yours,

R. G. Lawry.

1275 Old Colony Building, Chicago, Ill., May 15, 1905.

(The majority of reinforced concrete buildings thus far erected have been factory buildings, carrying heavy floor loads of moving machinery. Of course these conditions should be taken into account in designing the structure. We shall be pleased to hear from any of our readers who can give a more complete answer from direct experience.—Ed.)

Wanted: A Weed Killer for Use in Connection with City Streets and Sidewalks.

Sir: I should be indebted if you would give me any information in your possession with regard to the treatment of street weeds.

In this part of the world the greatest difficulty is encountered with a tenacious growth of weed, which forces its way through the joints of concrete flags, through the joints of freestone curbing, and the joints of sheet asphalt.

It may be imagined that if such a result occurs where the pathway is amply paved, it is a difficult matter to deal with those footpaths of the city which so far have not been paved, and which are of a very considerable extent.

In your last issue I read with interest certain experiments carried out in a portion of the United States with a chemical sprayed from a specially constructed tank

...with the result that weeds were entirely destroyed. ...appears, however, impossible to adopt the same prin... for streets here, first, because of the difficulty in ...ling the chemical, which is highly poisonous, and, ...dly, because of the method of treatment.

...perusing your interesting articles on Dr. Moore's ex...ments with sulphate of copper, I was bold enough to ...a solution of same on some of the street weeds, but ...ough 4 ozs. of copper to 60 gallons of water were ap..., no visible result was evident of the destruction of ...t life. Yours faithfully, F. Walton Jameson,
Borough Engineer.

...ietermaritzburg, Natal, April 14, 1905.

(We would suggest the trial of a saturated solu...on of common salt.—Ed.)

Opposition to the Alliance of Massachusetts Institute of Technology with Harvard University.

Sir:—There is such widespread misunderstanding of the attitude of the Faculty and former students of the Massachusetts Institute of Technology towards the proposed alliance with Harvard, that the public should be definitely informed, in as few words as possible, of the real grounds of the opposition of at least 90% of the men of those two bodies. College loyalty and sentiment, very properly, play a part in determining their attitude towards the suggested partnership, but it is a very minor one; the chief grounds of opposition are to be found in that commonsense, clear thinking and business caution which the Institute training does so much to foster. The theoretical advantages of such an alliance are indeed attractive; but when reduced to the practical details of a definite plan, based upon the actual conditions to be met, the objects desired can be but partially realized, if at all, and serious complications arise which make the experiment dangerous and unwarranted.

Four main arguments are used in urging Institute men to ratify this proposed alliance; (1) that it will bring in money; (2) that it will save money; (3) that it will broaden the Institute education; and (4) that it will promote the cause of higher education. Even were all these advantages to be secured, theoretically, through an alliance with Harvard, the Faculty and former students of the Institute object, by an overwhelming majority, to the practical means proposed. By this "Proposed Agreement" Technology is called upon to sign a contract vague and unbusinesslike in form, revocable at the will of either party, wholly contingent upon legal interpretations and decisions, pregnant with misunderstandings, and requiring the Institute to assume most of the present burdens and, in case of rupture, all future losses. The plea that this is a "gentlemen's agreement" does not reassure men accustomed as those of the Institute, to reading contracts and weighing their probable results. Long experience has taught them that such documents must sooner or later face the courts and that the law reads them as they are written, not as "gentlemen" may be willing to interpret them.

This "Agreement," moreover, requires the Institute to bury all her present resources in real estate near enough to Cambridge to share the disadvantages of that locality, but not near enough to partake of the real advantages of the collegiate environment; forces her to agree to reimburse the University in the event of annulment of the contract; and compels her to reorganize her government, to limit her choice of an executive board, and radically to change a policy which has given her the prestige she now holds—a prestige which has been attained, moreover, only because of her unique position as an independent institution.

Setting aside the question of the moral right of the University, even though she may secure legal permission, to divert bequests from their intended purposes, and assuming that the Supreme Court decides that a part of the McKay money may legally be spent at the Institute, even then this highly objectionable "Agreement" does not achieve what it is supposed to accomplish. Were it to be ratified, the Institute, for a generation to come, would secure from Harvard only money enough to pay the cost of teaching the Lawrence Scientific School students and would be compelled to bear the whole burden of providing for the natural expansion of the combined institution. The McKay Endowment, under this plan of alliance, would yield to the Institute only three-fifths of the net income of the estate for about fifty years, and the sum then available would be only three-fifths of the income of the accumulation of about five million dollars. To offset this, however, the Institute would lose at least two million dollars in bequests contingent upon her independence, would undoubtedly forfeit State support, and, most serious of all, would almost wholly cut off the present and future financial support (direct and indirect) of the more than six thousand former students who are now enthusiastically ready to assist her.

The plan of alliance will not save money for the Institute because it does not and—except by giving a cheaper and less thorough education—can not avoid duplication in either instruction or equipment. To save money in administration (following the example of business "mergers") is possible, but only on condition of making the Institute an integral part of Harvard University.

The plan will not really broaden the educational life of the Institute; it will merely substitute for the well recognized and thoroughly tested spirit of Technology the different spirit of the University. The students of the Institute, already pressed with the necessary work of their own courses, could find no time for intercourse with those of Harvard even were they to be admitted (as Dr. Pritchett says they are not) to the undergraduate classes of the University. The association of Harvard and Institute professors upon one Faculty is likely to lead to friction rather than to educational development, since the Harvard members to be injected are mainly heads of established courses. As to the broadening which is supposed to come from paying larger salaries to teachers, that cannot take place for at least fifty years, since neither the "Proposed Agreement" nor the McKay Endowment (until the death of the last annuitant) can provide higher salaries.

The projected alliance, finally, will injure, not help, the cause of higher education: (1) because it does away with competition, that leading stimulus to educational development; (2) because it creates a school too large for the only right kind of higher education—that which places every student under the immediate supervision of one or more members of the Faculty; (3) because it restricts the choice of youth seeking a higher technological education to one kind of institution in this educational center; and (4) because it brings to an end the great endeavor of Rogers, Runkle, Walker and their associates to build up, on a basis of science, modern languages, history and economics, a true university which shall meet modern conditions and needs more fully than can any of the older colleges. Yours truly,

Boston, May 13, 1905. M. I. T. Alumnus.

Engineering and Industrial Enterprises in and Near Denver.

Sir: During a recent trip to the East I spent several days in Denver, Colo., and have thought that perhaps your readers might be interested in the development of engineering and industrial enterprises in that vicinity.

Denver has not grown very rapidly during the past three years. The long-continued labor troubles in some of the most important mining sections of the state has greatly affected the general business of the city, which is so largely dependent on the prosperity of the mining camps. There has been a steady extension of the municipal improvements of Denver. Of these, the sewers come first in importance, with paved streets and alleys second. Besides the paved streets there are 40.7 miles that are surfaced with a layer of disintegrated granite.

The surfacing with the disintegrated granite is well adapted to the outlying residence streets. It gives a good finish to streets after they have been graded and curbed, and the cost has ranged between 25 and 30 cts. per sq. yd.

The most interesting piece of city engineering work projected for this year is the new bridge over Cherry Creek at Lawrence St. This is an 80-ft. street (the usual width in Denver), and the bridge takes the full width. The old bridge was taken down, and the two abutments were used to form part of the new ones. The new abutments cost about $8,500. The contract price for the superstructure is about $25,000. The latter work was let in December.

At the bridge site, Cherry Creek runs northerly, while the streets runs due northeast. The abutments are on a skew of 47° 50'. They are 109 ft. long between sidewalk girders, and 131 ft. long over all. The bridge has two spans of 78 ft. each. In place of a single pier there is a row of cylinder piers. Those under the main girders are each founded on five 12-in. piles driven 20 ft. into the bed of the creek. They are 5½ ft. in diameter. The cylinders under the sidewalk girders are 3¼ ft. in diameter. The piers are of concrete.

The superstructure is a plate-girder bridge. The two main or roadway girders are 46 ft. c. to c. and the two sidewalk girders are 13½ ft. outside of them. The fixed ends are at the center. The main girders are 8 ft. deep. The side ones are 7 ft. 8 ins. high and of lighter construction. The floor beams are spaced 17½ ft. apart. They are 4½ ft. high in the center, and less at the ends on account of the slope of the roadway. The two street-car tracks have an 18-in. I-beam under each of the four rails. The street-car lines in the city are all of 3½-ft. gage. The remaining I-beams are only 10 ins. in depth. The I-beams are supported by the floor-beams. The concrete floor or roadway is 6 ins. thick. The traffic comes directly on the concrete. The sidewalk is about 5 ins. thick on the inside and 8 ins. on the outside.

A new charter for the municipal government went into effect on Jan. 1, 1904. Under this charter the offices of city engineer and chief engineer of the board of public works, which had before been separate, were consolidated. The new office is that of engineer of the board of public works. The duties are so responsible that the office is next to that of the mayor in importance. The salary is $5,000 per year. The present engineer is Mr. John B. Hunter. The principal assistant engineer is Mr. H. P. Merryweather. Both these gentlemen have been connected with the municipal engineering work of Denver for most of the time for about twenty years past.

There has been a steady advance in irrigation development through the agricultural regions of the state. It is estimated that the acreage now irrigated is about 2,000,000. In 1900 it was 1,600,000, the cost of the systems to irrigate it having been over $11,500,000.

The main cause for the continued development since about 1898 has been the remarkable growth of the beet sugar industry. A number of irrigation enterprises that had proved to be flat failures have been rejuvenated by the profits found in raising sugar beets. During the past year it is estimated that 625,000 tons of beets, yielding 125,000,000 pounds of sugar, were raised. At a retail price of 5 cts. per lb. this amounted to $6,250,000. There are now nine sugar factories, having a total daily capacity of 6,850 tons of beets. It is estimated that 47,000 acres were devoted to beets during the past year. The producers get an average rate of $5 per ton for the beets. The average value of the crop per acre was about $66. The beet sugar industry has proved to be the key to the solution of the problem of putting to some profitable use the thousands of acres lying under a number of large irrigation systems that had never paid the owners. The experience with these had been typical of that of most of large corporate irrigation enterprises.

Colorado was one of the first of the states to place the operation of its irrigation systems under public control. The office of state engineer was created over twenty years ago. Various enactments have been made by the state legislature to more completely bring the irrigation system under control of the state engineer's office, but inadequate appropriations for the maintenance of the department have for much of the time made it impossible to carry out the full intent of the laws. The work of the state engineer's office has been greatly improved and expanded under the direction of Prof. L. G. Carpenter.

For purposes of administration, the state is divided into six main divisions, each constituting a distinct drainage basin, by which it is independent of the others. Each division is under charge of a division engineer. It is subdivided into a number of districts, in each of which a water commissioner has immediate charge of the distribution of the water to the different ditches. These commissioners make frequent reports of all operations to the head office. There are also in operation in a few places what is known as a "Special Service," where a daily record of the flow of water at ditch and river stations of a certain stream is made by the water commissioners or others in the state engineer's department, but where the services are paid for by the owners of the irrigation systems. These measurements are not required by law, but are useful in several ways to the water users.

Some new irrigation acts went into effect in July, 1903, by which all rights to water acquired after that time must be initiated by filing certain maps and statements in the office of the state engineer. Prior to that time, filings for water rights were made merely by custom. Under the new law, as well as the old one, the perfecting of the right depends on beneficial use. The court decree gives the legal right. However, many persons having previously-decreed rights have made new filings under the present law, in order to strengthen their rights. About 1,800 filings under the new law were made during the first 16 months of its operation. The law provides for a most complete and accurate survey of each reservoir site on a *natural* stream to be made by the state engineer's department. For other works the surveys are made by the owners.

During the past two or three years the construction of reservoirs has become the most important part of irrigation development in Colorado. The natural flow of the streams in the eastern portion of the state was long ago all appropriated, and for a number of years past the only considerable increase possible in the supply of water available for irrigation has been by storage. There are but few sites of any considerable size on the streams of the state, the best sites consisting of natural depressions, usually requiring dykes of some extent to complete the reservoir. Lately, two or three large projects have been initiated for the bringing of water from the west side of the main Rocky Mt. range over to the east side. Much of the run-off on the west side now goes to waste, because of no suitable lands to use it on.

The most important irrigation enterprise at present under way in the state is that of the U. S. reclamation service, to water lands in the Montrose and Delta valleys by bringing water from the canyon of the Gunnison River, for which a tunnel of 30,000 ft. length is required. The system will not be completed till the spring of 1908.

Very truly yours, W. P. H.

Salt Lake City, Utah, April 1, 1905.

Notes and Queries.

In describing the Cerro de Pasco Ry. in Peru in our issue of May 4, we gave the names of some of the engineers of the work, but omitted that of Mr. Anton Schneider, who was Division Engineer on the work from November, 1902, to February, 1903, and from the later date until September, 1903, was Acting Chief Engineer.

Information is desired concerning the present whereabouts of Frederick W. Frost, a structural steel draftsman, formerly employed by the firm of Levering & Garrigues, of 11th Ave. and 23d St., New York City, and re-

siding with his wife and children at 1909 Arthur Ave., Bronx Borough. On Feb. 12 last, the day following the funeral of an infant daughter, Mr. Frost left his home to go to a nearby store and has not been seen or heard from by his family since. Mr. Frost is 24 years of age, 5 ft. 11 ins. in height, has blue eyes, brown hair and pale complexion, and a smooth-shaven face. Any information concerning him may be addressed to his wife, Mrs. Etta A. Frost, 1909 Arthur Ave., Bronx Borough, New York City.

TESTS OF COPPER AND IRON SULPHATES AND LIME WITH MECHANICAL FILTERS AT ANDERSON, IND.

The installation of a mechanical filter plant at Anderson, Ind., during the past winter afforded an opportunity for testing under working conditions some of the recent laboratory deductions as to the efficiency of copper sulphate as a typhoid germicide. Although to our minds the tests were far from conclusive as to the value of copper sulphate as compared with either sulphate of alumina or sulphate of iron, they are certainly interesting, and, together with the investigations leading up to them, seem to warrant more extended tests. It should also be observed that the tests have no bearing upon the objections in the minds of thousands to the injection of powerful chemical agents into drinking water, except that during the tests only minute quantities of copper were used.

The information which we give below is taken from a paper by Mr. C. Arthur Brown, of Lorain, O., read on May 11 before the American Water-Works Association. It is only fair to our readers for us to state that Mr. Brown now represents a company that for several years has been introducing sulphate of iron in place of sulphate of alumina as a coagulant and that recently Mr. Brown and the company have been at work on the combination of the sulphates of copper and iron, so as to produce an agent which will serve as both a coagulant and a germicide.

In opening his paper the author stated, in substance, that 1 part of copper sulphate per 100,000, as had been proposed for a germicide, was prohibitive in point of cost; that the 12 hours or more required for reaction when the copper is merely added to water is prohibitive in connection with most mechanical filter plants; that the copper when used alone will go through filters; that the addition of sufficient lime "to absorb all the free and a portion of the semi-combined carbonic acid" will prevent the appearance of copper in the filtrate, and that lime is necessary to combine with iron when sulphate of iron alone is used; that the long period required for the action of copper sulphate when merely added to water is due not to the necessity for a long contact of the copper with the bacteria, but to the time needed to bring the copper and the germs *into* contact; and finally that a very small amount of copper, when used with lime, will produce sufficient hydrate of copper, spread over the filter surface in a thin film, to afford the necessary contact and eliminate pathogenic germs. This elimination, however, is by a *selective* process, the total bacterial reduction not being high, and the proof of the selective process being founded, so far as given in the paper, on the presence of coli communis bacteria in the untreated and its absence in the treated water.

About the time that the new mechanical filters at Anderson, Ind., were nearing completion the manufacturers of sulphate of iron arranged with the city authorities for a comparative test of the sulphates of alumina and of iron. Mr. Brown had been chosen to represent the filter manufacturers (and presumably the makers of sulphate of iron). The city was to be represented by Mr. Severance Burrage, Professor of Sanitary Science at Purdue University, and by Dr. S. C. Norris, City Chemist. Before beginning the tests, which were to extend over 20 days, half with alum and half with iron, the plain iron sulphate was replaced by three lots, containing 1, ½ and ¼% of copper sulphate. Meanwhile arrangements were made for the cooperation during the tests of the U. S. Department of Agriculture, represented by Dr. Carl Kellerman.

The water supply of Anderson is taken from the White River, which receives the sewage of Muncie, 25 miles above. At the time of the tests the river was ice-bound, thus freeing the contained bacteria from the action of sunlight and air.

Four of six filters had been completed and were tested. These are of concrete construction, 12 × 36 ft. at the water level, giving an area of 350 sq. ft. each. The filters are designed for a capacity of 1,000,000 gallons each per 24 hours, and the controllers were set at that rate, surplus water above the consumption being wasted. It appears from Mr. Brown's statements that proper means had been provided and were used for mixing and regulating the admission of the chemicals into the suction pipe before the water was pumped to the settling basin.*

The balance of the paper, with slight condensation, and the placing of some of the text as notes to the diagram, is as follows:

Previous to starting the test, it was agreed upon by the four analysts that the end to be obtained was a water free from B. coli communis. It was understood that enough alum should be used to attain this result if possible, and that enough iron containing copper should then be employed to bring about the same result.

The test started using one grain of alum per gallon of water filtered. The colon was found present in the filtrate and the alum was raised to two grains per gallon and then to three, but the B. coli did not drop out. A very poor coagulation resulted even from this amount of alum. No cause is known unless the large amount of chlorine and organic matter retarded the coagulation or induced a colloidal suspension of the same. Lime used in connection with alum did not materially improve the coagulation and did decrease the amount of color removed. When sulphate of iron containing 1% of sulphate of copper was applied at the rate of 1½ grains per gallon, the colon bacillus dropped out immediately. Even when a ½% sulphate of copper-iron sulphate was employed and 1½ grains per gallon used, the same results obtained. When a ¼% mixture was employed a break occurred and the colon appeared in the filtrate as it did when straight sulphate of iron was used. When we went back to a 1% mixture it instantly dropped out on all four filters.

At no time was copper found in the filtrate, even when 4½ grains of 1% mixture was used. Not even a trace could be found by concentrating large volumes of water. Ferrous iron could not be found in the filtrate, though small quantities of ferric iron were present. This amounted to about 0.2 or 0.3 parts per 1,000,000. The accompanying diagram and notes will give a good idea of the results obtained.

It will be seen from a study of the diagram that the colon bacillus was present in the river water in every sample taken, save two, during the 22 days' test. In the ten days' time during which alum was used, the colon bacillus was present in the settling basin in every sample taken save one. As soon as the sulphate of iron containing copper sulphate began to be used the colon bacillus appears only periodically in the water coming from the settling basins. On Feb. 22 when no copper was employed it is shown to be present in both samples.

As will be seen, a series of small figures have been inserted at the points showing presence of colon in the filtered water after sulphate of iron containing copper sulphate began to be used. An explanation of these figures is given in the notes below the diagram.

It will be seen that there is a break in the chart on the morning sample of the 18th, no samples being taken at this time. The centrifugal pumps were closed down to effect the removal of the incrustation caused by the application of lime to the suction of these pumps.

As is to be expected, the tap samples follow in a general way the composite of the filters, the curve being a little slower, as the tap samples were taken uptown, and several hours would elapse before the water reached the tap.

With alum 20 samples were taken from the river, 20

*It is interesting to note Mr. Brown's statement that milk of lime or lime water can be passed through a pump without material trouble, but that a mixture of these with water will cause incrustation of either a piston or centrifugal pump that will throw it out of commission.

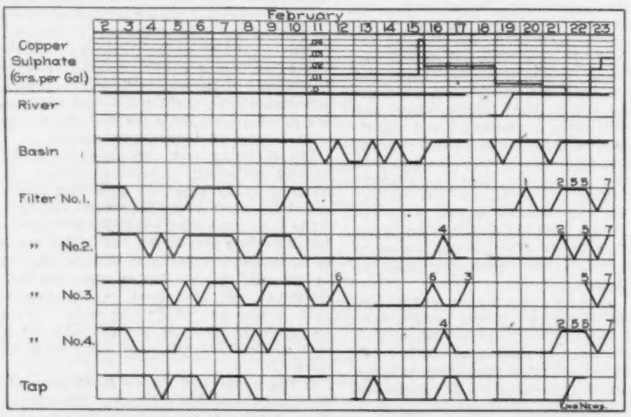

DIAGRAM SHOWING PRESENCE OR ABSENCE OF B. COLI COMMUNIS AND AMOUNT OF SULPHATE OF COPPER USED, IN TREATING WATER AT ANDERSON, IND.

From Feb. 2 to 11, inclusive, alum was used. From the 12th to the 23d, inclusive, sulphate of iron (and copper.—Ed.) were used. On the 22d the sulphate of iron used contained no sulphate of copper. The amount of copper sulphate employed from day to day is indicated by the black line, plotted in above the B. coli results. From the morning of the 12th until 6 p. m., Feb. 15, .015 of a grain per gallon of sulphate of copper was used. From 6 p. m. until midnight of the 15th, .045 of a grain was used; from midnight of the 15th until midnight of the 18th, .0225; from midnight of the 18th until midnight of the 20th, .0075 of a grain was used; during the 21st, .00375; from midnight of the 22d until noon of the 23d, .0189; from noon of the 23d until midnight of the same day, .03 of a grain was employed.

The equivalents of the different rates of copper sulphate used are:

Grains per gallon.	Parts per 1,000,000	Or
.00375	.064	1 to 15,576,000
.0075	.128	1 " 7,783,000
.015	.256	1 " 3,894,000
.0189	.325	1 " 3,091,000
.0225	.428	1 " 2,336,000
.03	.513	1 " 1,947,000
.045	.770	1 " 1,298,000

Explanation of Figures at Points on Diagram.

(1) Filter 1 shows colon present on this occasion, only .0075 of a grain per gallon of copper sulphate being employed. During this period the filters were running very irregularly owing to the fact that one of the settling basins was being filled and the probabilities are that the application of the chemical was irregular.

(2) This appears on Filters 1, 2 and 4. Only .00375 of a grain of sulphate of copper per gallon was employed, 1.5 grains of sulphate of iron containing ¼ of 1% of sulphate of copper being used at this time. This is evidently too small a quantity to handle as badly a contaminated water as existed at Anderson.

(3) This appears on Filter 3. Previous to the time of taking this sample this filter was being used experimentally and the operation seriously interfered with. We expected colon to develop in this sample.

(4) This appears in Filters 2 and 4. From 6 p. m. until 12 p. m. of the 15th, 4.5 grains of sulphate of iron containing 1% of sulphate of copper was employed. When we left the laboratory at midnight, it was seen that this large amount of coagulent was going to cause trouble. We instructed the night man to reduce it to 2¼ grains. In attempting to do so he entirely closed the valve and no coagulant entered the water for several hours. This allowed contaminated water to pass the filters, and at the next washing the contaminated water from the clear well again contaminated the filters, and near enough the time of sampling to show B. coli in two of the samples.

(5) This appears on Filters 1, 2, 3 and 4 during Feb. 22, and is occasioned by sulphate of iron containing no sulphate of copper.

(6) This appears on Filter 3. A leak in the air pipe was discovered on Feb. 11 and 16, which permitted the unfiltered water to enter the filtered water without passing through the sand. Colon being present in the settling basin on both occasions, it was logical to expect to find it in Filter 3 under these conditions.

(7) This occurs in Filters 1, 2, 3 and 4. Previous to taking these samples a ten-gallon culture of B. prodigiosus had been injected into the water entering the settling basins and only a few seconds after the sulphate of iron was applied to the water. It has been ascertained by the Bureau of Plant Industry (U. S. Dept. of Agriculture.—Ed.) that such amounts of bouillon are sufficient to render the copper sulphate innocuous, thus explaining these four samples.

From Feb. 2 until 8 p. m. Feb. 3, one grain of alum was used; from 8 p. m. of the 3d until 8 p. m. of the 4th, two grains; from 8 a. m. of the 4th until 8 p. m. of the 9th, three grains; from 8 p. m. of the 9th until 8 p. m. of the 10th, two grains; from 8 p. m. of the 10th until 6 p. m. of the 11th, 1.5 grains of alum and two grains of lime were used. Thirteen runs were made with iron sulphate, varying the amounts of iron, lime and copper.

from the settling basins and 80 from the filters. All the river samples contained B. coli. Out of the 20 settling basin samples taken 95% of the samples showed presence of B. coli; and out of the 80 taken from the filters, 47 of them, or 59%, contained B. coli.

Out of 23 samples from the river during the time sulphate of iron was employed, 21 showed B. coli. Two samples from the settling basin on Feb. 22 contained B. coli, straight sulphate of iron being used. On Feb. 21 ¼% of sulphate of copper mixture was employed, and one of the two settling basin samples contained B. coli. During the rest of the time 1% or ½% mixture was employed, and out of 19 samples taken from the settling basin 12 of them, or 63% of the samples, contained coli; thus showing nearly as good removal by sedimentation alone as was obtained by sedimentation and filtration with alum. During this same period, if we exclude the accidental errors as explained by the notes, we have a complete or 100% removal by sedimentation and filtration using sulphate of iron containing not less than ½% of sulphate of copper. Using 1½ grains of iron sulphate containing ½% copper sulphate gave perfect filtration results, therefore, no better could be obtained by using larger amounts.

Owing to minor defects in construction, the percentage removal was low. While alum was used, the average number of bacteria in the river was 67,660, in the effluent of settling basins 26,856, and in the filtrate 5,539; showing a percentage removal of 91.81. During the time iron was used, the corresponding figures were 38,234, 26,339, 3,887, with a reduction of 89.80%. The average amount of alum used was 2.5 grains per gallon, and of iron sulphate 2.0 grains.

The average cost for chemicals was $3.16 per 1,000,000 gallons for alum, and $1.97 for iron sulphate and lime; a saving of $1.00 for the iron sulphate process. The cost was based on alum at $18 per ton, iron sulphate at $10 per ton, and lime at $6 per ton, f. o. b. Anderson.

It will be seen that the alum exercised no selective tendency in removing or killing the pathogenic bacteria. It effected only a percentage reduction, and iron sulphate containing no sulphate of copper followed the same rule; but with iron sulphate containing these small amounts of sulphate of copper there is seen to be a selective action present. The amount of copper sulphate was large enough and the contact long enough to kill or remove the colon bacillus, even when only 1.5 grains of sulphate of iron containing ½% of copper per gallon was employed. This is equivalent to .0075 of a grain per gallon of sulphate of copper, .128 parts per 1,000,000 of sulphate of copper, or 1 part of copper sulphate to 7,788,000 parts of water. Under the best practice using alum or straight sulphate of iron only a percentage removal could be obtained.

It has been seen that the percentage removals at Anderson were very low, even with skilled attention. It is probable that other plants of first-class construction and in perfect conditions will, under less careful management, produce equally as poor or even worse percentage results. It will be noted that with alum, as used at Anderson, no selective action was apparent. The alum removed a percentage of all bacteria present, having no apparant tendency to pick out and exterminate the dangerous bacteria. This, as far as we know, is universally true. It follows from this that if there be 100,000 bacteria present in a water and it is filtered by any of the older processes, it is almost a certainty, even if 99.99% of all these be removed, that some of the pathogenics will slip through and may cause a higher typhoid rate than is desirable. With lower percentage removals the danger from this cause must increase very rapidly on a badly contaminated water.

The work at Anderson has proven that even on a water as heavily sewage laden as exists there, and with only 89.80% removal, it is possible to completely eliminate all B. coli and assumedly all B. typhi. There is every reason to believe that this process will effect a larger percentage removal than would be obtained without the addition of the copper sulphate on a plant in first-class condition. It is thought this marks an important advance in the art of filtration, and gives the mechanical filter an important advantage over any simple percentage removal process.

THE PHILADELPHIA GAS EXTENSION LEASE.

The notorious Philadelphia gas extension lease ordinance was passed on May 18. The vote in the common council was 74 to 9, and in select council 37 to 4, making a combined vote of 111 to 13, with only one member absent from each branch. At the last moment the ordinance was amended to provide for a future reduction of rates. The ordinance was scheduled for passage two weeks earlier, but protests from the mayor, the press, and citizens led councils to advertise for bids. This, as we pointed out editorially in our issue of May 11, was a farcical proceeding, designed as a blind, since it was well known that only the present lessee could put in a bid that would be considered, even if time sufficient for the preparation of bids had been given.

On the expiration of the paltry ten days' call for bids, the only attempt at competition was a joint proposition by a banking house and a local daily newspaper, providing for a loan to the city, to be repaid from the revenues from the gas works, and for a percentage of the revenues left after providing for capital charges on the loan. The proposition also provided for the payment, in 1907, of the sums expended by the present lessees for extensions to the works as required for cancelling the old lease by the city, but limited the sums to a total of $20,000,000. As the city has no check upon the expenditures for improvements made by the present lessee, and as various other features of this bid were equally uncertain, it was easy for councils to make out a claim that this bid was disadvantageous to the city, even had the bidder been experienced in the operation of gas works. In addition to its destructive criticism of this bid, and in justification of the lease originally proposed, council's committee presented an exhibit showing a grand total of more than $49,000,000 needed for various public improvements, against a legal borrowing capacity of $15,000,000, and a tax rate of $1.50, which latter, it urged, ought not to be increased. The proposed lease extension would provide $25,000,000 of practically immediately available money, without bond issue or addition to the tax rate. A plea from the mayor for delay and for a conference with the committee to discuss the situation was unheeded; but to soothe the public there was introduced at the last moment, and carried, an amendment reducing the rates for gas to private consumers to a straight $1 a thousand until 1928 and 90 cts. thereafter, and further reducing them by degrees to 80 cts. in 1956, where they would remain until 1980. In this form the ordinance passed by the large majorities already mentioned. It is understood that the mayor will veto the ordinance, but that it will be passed over his veto at the next meeting of councils, June 1.

To summarize: By the extension ordinance the city commutes for $25,000,000 the yearly percentage of gross revenue which the company would pay it until Dec. 31, 1927, surrenders the privilege of resuming control of the works at the cost of improvements and interest thereon to date in 1907, and extends for 53 years, or from 1927 to 1980, the date at which the works, with all improvements and extensions, would otherwise revert to the city without paying the company a cent.

A FATAL ACCIDENT WITH A STEAM TURBINE.*

On April 20 a fatal accident occurred at Messrs. Sir B. Samuelson & Sons, Ltd., Newport, Middlesbrough, through the failure of the steel shaft of an air turbine used in connection with a Parsons steam turbine for supplying air to the blast furnaces. As a consequence of the failure of the spindle, the air turbine and casing were completely wrecked, while two men struck by the flying fragments were killed on the spot.

At the inquest evidence was given to show there was nothing unusual in the working conditions, the speed at the time being 3,000 revs. per minute and slightly below the normal rate; while on Jan. 16 the turbine, which was put down about 12 months ago, was thoroughly examined and then found in order.

Mr. J. E. Stead, F. R. S., who made a special investigation of the failure, said he examined the fragments of the fractured spindle just after the accident occurred. They were distributed very widely, and, at his suggestion, the fragments were assembled and the spindle built up again. He found that all the fractured pieces except on one side were very irregular in shape. On the other side there was a straight fracture running longitudinally through the spindle, and he was of opinion that it was through this line the original fracture ran, and that it first started at the inlet end of the blower. He had carefully examined the fractured surfaces, but could find no flaw in the steel; but these were more or less rusted, and it would be difficult to detect any flaws, even if they were there. He had tested samples of the fractured shaft and found a tensile strength of 42 tons per sq. in. longitudinally and 38 tons transversely at the point where the fracture appeared to have started. The elongation was 12½% in a length of 3 ins. longitudinally and 4.7% transversely at a point near the base of the spindle. Chemical analysis revealed nothing peculiar except that the steel contained a rather high percentage in carbon. The material, in fact, seemed good. He could only conjecture as to the cause of the fracture. Any steel was liable to have incipient flaws in it which it was impossible to detect in the forge or the engineering workshop, and it was possible such a flaw had existed and yet be impossible to detect by superficial examination. The place where the fracture occurred was weakest, but even here the factor of safety was nine.

Mr. G. Stoney, chief technical manager for C. A. Parsons & Co., the makers of the turbine, agreed with Mr. Stead's explanation of the accident. The engine, before leaving the works, was, he said, tested to 3,800 revs. per minute, and behaved with perfect satisfaction. This was, he said, the first accident his firm had experienced with any turbine.

As a result of the inquest, a verdict of "accidental death" was returned.

*From "The Mechanical Engineer," of Manchester, England.

HEATING, VENTILATING AND AIR COOLING THE NEW STOCK EXCHANGE BUILDING AT NEW YORK CITY.

One of the most elaborate heating systems ever installed is that now in operation in the new Stock Exchange, Broad St., New York City. The circulation of air through the building is maintained by eight Sturtevant centrifugal fans and three disk fans. For the rooms devoted to the transaction of business, the ventilating plant is designed to supply air under a slight plenum, and also to exhaust it by mechanical means, the combined capacity of the exhausting apparatus for these rooms being somewhat less than that of the plenum apparatus. This arrangement provides that a positive outflow may take place from the spaces requiring ventilation without creating a tendency for an inflow of cold air through such openings as the building may possess.

The supply fans are equipped with tempering coils, each of which is controlled by a pair of thermostats, one fixed in the cold-air duct and controlling two sections first encountered by the incoming air, and the other in the hot-air duct, controlling the remaining sections of the tempering coil. Each section of a group is fitted with a hand valve.

The total contents of the building is 2,706,000 cu. ft. The air which the system is capable of supplying is figured as 200,300 cu. ft. per minute, while the exhaust system has capacity to handle a total of 224,540 cu. ft. in the same period of time.

An interesting detail is the provision in each tempering chamber of a moistening pan for maintaining the air, under automatic control of a humidostat, at the desired degree of humidity. Each pan is furnished with submerged steam pipe coils to set up evaporation, and with an automatic water-feed valve for keeping the coils submerged.

In general the ventilating system is designed to effect, on an average, six changes for the fresh-air side and five for the exhaust-air side of each system per hour. The excess is largely disposed of through the doors to toilet rooms, which are ventilated at the rate of fifteen changes per hour without special fresh-air supplies. There are a few special cases where an excess of exhaust over supply is provided, on account of the relatively high degree of vitiation or the presence of disagreeable odors. One of the locker rooms, for example, has five changes on the fresh-air side, and eight on the exhaust side; and several hat and coat rooms, four and eight changes respectively.

The air filters are of the usual cheese-cloth type, set in frames fixed in a zigzag fashion, with galvanized wire netting to support the cheese-cloth. The total area is about 5,400 sq. ft., so that, on a basis of a total flow of 200,000 cu. ft. of air per minute, the velocity through it is 0.6 ft. per second. About 50 filter frames are taken out each day for cleaning, the reserve number in storage being equal to that in use, and this arrangement results in the entire filter being cleaned in a period of two weeks. For cleaning the filter sections, a special Sturtevant fan is installed in a room adjoining the cold-air chamber. To the suction side of this fan is built a special hopper inlet, which is large enough to receive one frame, and with the suction of the fan and the application of a broom, the particles of dust are loosened from the cheese-cloth and discharged finally out of doors.

The entire system was designed by Alfred R. Wolff, of New York, and the blowers were furnished by the B. F. Sturtevant Co., of Boston.

THREE IMPORTANT RAILWAYS for new transcontinental routes are respectively completed, under construction and projected. The first of these is the San Pedro, Los Angeles & Salt Lake Ry., which was opened a few months ago, and gives a direct route of about 780 miles from Salt Lake City to the coast towns of Southern California and to the new port of San Pedro, as against the former route of over 1,200 miles in length by way of Sacramento. We shall publish some particulars of this later. The second line is the Denver, Northwestern & Pacific Ry., which is being built from Denver to Salt Lake City, and has recently been described in our columns. The third line is the Western Pacific Ry., projected from Salt Lake City to San Francisco and intended to give the Gould system a line to the Pacific, as it has already recently completed a line east to Pittsburg and the Atlantic. It is reported that a route has been found with a summit elevation of about 5,000 ft., and with maximum grades of 1%.

AN INTERURBAN OR LOCAL TRAIN SERVICE to forestall a possible demand for an electric interurban competing line has been established by the Illinois Central R. R., between Chicago and Kankakee, 55¾ miles. The fare is 90 cts. for the entire distance, or $1.45 for the round trip; no baggage is carried. The trains stop at regular stations and at road crossings. At present each train consists of an engine with one car, but the introduction of motor cars for this service is being considered. A similar local service established by the Chicago & Alton Ry., to meet the existing demands of electric lines was recently noted in our columns.

DOUBLE-END WATER TUBE BOILERS have been installed in the power-house of the Philadelphia Rapid Transit Co., at Second St. and Wyoming Ave., Philadelphia, by the Parker Boiler Co., of that city. The boilers are of the Parker horizontal-tube type (described in our issue of Aug. 22, 1901, p. 127; see also a test report on the boiler in our issue of Nov. 27, 1902, p. 457), and have a capacity each of about 700-HP. normal though they have developed nearly 945-HP. in a 24-hour capacity. They differ from the single-ended boilers of the same type mainly in having a slightly-changed arrangement of the baffles and a central uptake. These double-end boilers also have superheater elements fitted. They are composed of several coils of tube located just above the baffle-plate forming the roof of the furnace.

SIX DEEP-WELL PUMPS, operated by suspended rods from a central station, have recently been installed for an individual at Balaklava, South Australia, with A. R. Johnstone, of Adelaide, as contractor. A 12-HP. oil engine is located near the center of the group of wells, the most distant of which is 1,500 ft. away. The engine drives a 9-ft. wheel with two cranks which swing the 6-ft. horizontal wheel by pitmans. The ends of the rods leading to the wells are pivoted at various points on the horizontal wheel. Each well is 8 ins. diameter, and the water rises to about 80 ft. from the surface. The pumps are 4¼-in. deep-well working barrels, 24-in. stroke, making 25 strokes per min.

ELECTRIC MOTOR-DRIVEN CENTRIFUGAL PUMPS are in use to operate a hydraulic elevator plant in the John Taylor Dry Goods Company's store at Kansas City, Mo., a building occupying an entire city block. Current is supplied to the entire establishment by three direct connected generator units, two of 75-K.K. and one of 160-K.W. capacity. The elevator pumps are three in number, two being driven by a 45-HP. motor and one by a 70-HP. They are designed to maintain a pressure of 140 lbs. in the pipe system. The pumps are Worthington three-stage turbine pumps. There is one pressure main from the discharge openings of the pumps, which runs throughout the whole building past each of the elevator machines. This pressure main is connected into a compression tank in each end of the building, these two tanks being set at the same level and carrying their water lines at the same height. The connection for each elevator machine is then taken from this main at a convenient point. There is a discharge or return main paralleling the pressure main into which each elevator machine discharges, and this return main is connected to each of two open, or "surge," tanks located near the compression tanks, then continuing on and connecting to the suction of the pumps. With a suitable arrangement for "snifting" entrained air out of this suction line, the operation of the system is perfect.

The capacities of the three units were chosen to fit the service requirements with a single unit or combination of units at all times throughout the variations of load during a day's run, while at the same time providing a reserve capacity for accidents, or contingencies. During the hours of light load, one of the 300-gal. units operating at normal capacity will carry the service. During the hours of heavier service the 500-gal. pump, No. 3, will take care of the load, and during the hours of maximum load either machines No. 1 and No. 3, or machines No. 2 and No. 3, together, will carry the load; or No. 1 and No. 2 will carry the service, if conditions demand slightly less than maximum capacity and more than the normal capacity of machine No. 3. These sizes were determined upon after a very careful study by the engineers, in advance of the installation of the elevator equipment. Experience has demonstrated that the proportions determined upon were right and the service has been all that has been and could be desired.

A governing motive in the adoption of the design was the compactness of the installation, there being available a total floor space of only 160 ft. The importance of compactness will be more fully realized when it is stated that this installation is two floors below the ground in a sub-basement in which there are many building columns and other obstructions and where a very limited space was allowed to the engineers for the mechanical equipment. This plant was designed in all its details and its construction superintended by the Engineering Office of W. K. Palmer, 718 Dwight Building, Kansas City, Mo.

THE NEW YORK WATER SUPPLY COMMISSION bill has been signed by Mayor McClellan, and he has invited the Chamber of Commerce, the Manufacturers' Association and the New York Board of Fire Underwriters to name three men, residents and citizens, as possible appointees. From each group of three the Mayor proposes to select one man to serve on the commission. Each commissioner will have a salary of $12,000 a year. They are virtually limited, we understand, to Esopus Creek as a source of supply, and their plans must be approved by the recently created State Water Supply Commission, the members of which have not yet been named by Governor Higgins.

WATER PURIFICATION or new supplies, by June 1, 1906, have been ordered or advised by the State Board of Health of Vermont for the cities of Burlington and Vergennes, and the towns of St. Johnsbury, Enosburg Falls and Swanton.

BIDS FOR 30,000,000-GALLON WATER SOFTENING and purification plants are wanted until June 15 by the Board of Public Service, Columbus, O. Hering & Fuller, 170 Broadway, New York City, are consulting engineers for the work.

A MUNICIPAL MUSEUM was opened in Chicago a few weeks ago. It is housed in the Chicago public library building, and includes exhibits, loan and permanent, of drawings, models, photographs and literature relating to municipalities. In addition to the exhibits, lectures on various municipal topics are being given twice daily five days in the week. The museum was founded by the City Homes Association of Chicago, and was incorporated in November, 1904. Mr. Geo. E. Hooker is Secretary, Mr. E. G. Routzahn is Assistant Secretary, and Mrs. Conde Hamlin, director of exhibits. A few weeks ago a special exhibition in public hygiene, with lectures, was held under the direction of Mr. Charles B. Ball, M. Am. Soc. C. E., 118 Hazel Ave., Chicago.

STATE ROAD BUILDING IN ILLINOIS HAS BEEN provided for to the extent of a $50,000 appropriation for trial work during the two years. The bill has just been signed by the governor. Another bill signed by the governor provides that upon petition of the state highway commission, the authorities of the State penitentiary and reform schools shall employ convicts to make culvert pipe and to prepare road material, free of charge.

AN EXHIBITION RAILWAY COLLISION occurred on the railway connecting the Westinghouse works at Wilmerding, Pa., on May 16, being arranged for the benefit of the International Railway Congress delegates. A train of 50 steel cars equipped with Westinghouse friction draft gear was divided into three sections and the locomotive and one section backed into the middle section at a speed of 40 miles per hour, sending it bumping into the last section. Reports state that the cars and draft gear were uninjured by the severe test, and that it was repeated with the same rolling stock, an electric locomotive taking the place of the steam locomotive first used.

A PLAN FOR A 60-FT. ROADWAY TUNNEL under the East River has been submitted to the Rapid Transit Commission of New York by Mr. D. D. McBean. The plan is based upon the method devised by him for the Tower Hill Tunnel on the New York Subway, but with modifications that simplify the work and do away with much of the obstruction to navigation. Briefly described, the plan is as follows: The site of the tunnel is dredged to a proposed depth, and piles are driven about 4½ ft. apart and cut off about at the elevation of the base of the proposed roof and properly capped. Upon this pile foundation is then lowered a roof section made of a single layer of braced plate girders imbedded in concrete and covered on top with steel plate, also imbedded in concrete. This roof section is floored and bulkheaded so that it will just float, and is sunk in position by some added weight. When this roof rests upon the piles, heavy sheet piling is driven down longitudinally close to and along the outer line of the sides of the roof; the excavated portion is then filled in over the roof. Under the protection afforded by the roof, the sheet piling sides and the end bulkheads, the bottom is excavated, the piles cut off at the proper level and the bottom and side walls are built of concrete, waterproofed on the outside limits by brick laid in hot asphalt. All of this is done under compressed air. To meet the principal objection to roadway tunnels under rivers—the cost of approaches to the tunnels—Mr. McBean proposes to avoid these approaches altogether by terminating the roadway tunnel just inside the bulkhead lines, and there establishing vertical shafts equipped with elevators of sufficient size to handle the traffic. It is also possible to place two street railway tracks in this tunnel, leaving two 18-ft. driveways, and to extend these tracks in small tunnels under the street surface to a connection with the subways. The designer claims that several such roadway tunnels can be constructed for the cost of one East River bridge.

A COKE AIR WASHING APPARATUS has been installed in connection with the heating and ventilating of the office building of the H. K. Porter Co., located in the heart of the Pittsburg manufacturing district. The entire equipment was designed and installed by the B. F. Sturtevant Co., of Boston, through its local Pittsburg office. The heating apparatus consisting of fan, heater and belted motor, is installed in the basement in conjunction with the washer which consists of a metal supporting frame filled with broken coke, over which water is allowed to trickle. The air as it passes between the fragments of coke is thoroughly cleansed of smoke and dust, which is washed down by the water to the bottom of the device and there removed. Previous to the installation of this plant, drawings, papers and the like became very dirty. It is now reported that they are kept perfectly clean at all times, owing to the fact that no air can enter the building except through the heating apparatus where it is thoroughly cleansed. If Pittsburg air can be washed clean, there is surely hope for every other city.

THE CONDITION OF RAILWAY REPAIR SHOPS was illustrated recently in discussion before the Western Railway Club by Mr. M. K. Barnum with the following figures. For two railways, neither of which can be considered far from the average, a list of all the machine-tools owned by the road shows ages as follows:

Age of Tools	—Railway No. 1— No. of Tools	Per cent. of all Tools	—Railway No. 2— No. of Tools	Per Cent. of all Tools
Less than 10 years old..	517	33	193	24
10 to 20 years old	472	31	269	33
20 to 30 years old	193	12	113	14
30 to 40 years old	137	9	102	12½
40 to 50 years old	15	1	12	1½
Not known, but very old	211	14	125	15
Total.....	1545	100%	814	100%

The distribution of machine-tools among the different departments of the repair shop was shown by the following table.

ITEMS	—Shop A— No. of tools	Value	—Shop B— No. of tools	Value	—Shop C— No. of tools	Value	—Shop D— No. of tools	Value	—Shop E— No. of tools	Value	—Shop F— No. of tools	Value
Machine shop.....	30	$16,655	50	$56,573	122	$134,975	113	$99,043	160	$133,816	178	$196,400
Tin and pipe shop (includes bench tools).....	12	105	11	400	48	383	20	2,700	42	630	55	850
Boiler and tank shop (includes furnaces, clamps, etc.).....	6	750	6	5,724	36	25,680	23	21,327	23	24,450	24	48,580
Blacksmith shop (includes hammers, etc., but not forges).....	1	1,200	5	3,746	15	14,350	13	11,957	12	15,450	25	18,500
Planing Mill		None	24	10,154	33	12,681	57	12,383		None		None
Total.....	49	$18,710	96	$76,597	254	$188,069	226	$147,410	237	$174,346	282	$264,330
Shop holds—Locomotives ..		5		9		16		22		22		50
Capacity — Locomotives a year.....		60		120		216		300		300		600
Area locomotive erecting shop, sq. ft.....		...		13,163		19,688		30,000		26,532		85,854
Area machine shop, sq. ft...		...		20,837		19,687		44,600		44,220		74,605
Area boiler and tank shop sq. ft.....		...		13,320		22,620		56,730		25,232		77,503
Area—Total three shops, sq. ft.....		...		47,320		61,995		131,330		95,984		237,962

THE CORROSION OF COPPER BY SEA WATER is preventable, according to recent studies by the German naval authorities, by a very simple expedient; opposing the tendency to chemical action by an oppositely-directed electrochemical potential. This is accomplished in simple form by placing an iron or steel network in contact with the copper surface to be protected. The action which results is, first, an attack of the iron by the sea water, and, second, an adherent deposit of iron oxide gradually forming on the copper; when this coating is formed the rusting of the iron decreases in rapidity. To protect copper piping by this method it was found most suitable to insert a helical coil of spring-steel wire in the pipe, in such a way that the wire is in firm contact with the inner wall of the pipe. By using a wire of flat cross-section the clear area of the pipe is not much decreased. Wire 1-16-in. in diameter is said to be ample for ordinary sizes of piping; the pitch of the helix may bt about equal to the diameter of the pipe. In the case of condenser tubes, where it is desired to preserve the full area of tube cross-section as nearly as possible, a helix of very steep pitch may be used, of suitably larger wire. Long-time tests of the method were made at the Danzig navy yard, using pieces of pipe made of furnace copper, electrolytic copper, brass, and pieces made of a half section of copper pipe brazed to a half section of brass pipe. In all cases the iron wire helix was found to prevent corrosion in a 3.5% salt solution and in sea water containing 3.5% of solids. When the iron protection was present, the pipes showed a gain of weight, while without the iron protection a loss of weight was observed in all tests (periods of 30 to 198 days.). The wire used was only ½-mm. (0.02-in.) thick, but yet had not rusted through or lost its elasticity during test periods of 18 months. In commercial application of the method it will be necessary to take care of the strong initial rusting by washing out the pipes before drawing water for use.

THE USE OF FUSED QUARTZ has progressed so far during the two or three years since fused quartz was first used for the commercial production of physical apparatus that mercury-vapor lamps of fused quartz are now being made. W. C. Heracus, of Hanàu, Germany, the first instrument maker to take up fused quartz manufacture, is making these lamp tubes, according to a report of Consul-General Guenther, of Frankfurt, Germany.

PERSONAL.

Mr. Holland Wheeler has been appointed City Engineer of Lawrence, Kan.

Mr. Albert Rhame has been appointed City Engineer of Red Wing, Minn.

Mr. Garnet D. Baltimore has been appointed Landscape Engineer in the Park Department of Troy, N. Y.

Mr. F. Neher has been appointed Principal Assistant Engineer of the Missouri Pacific Ry., with headquarters at St. Louis, Mo.

Mr. Manuel de Diaz has been appointed Chief Engineer of the Department of Public Works, of the Province of Santiago de Cuba.

Mr. R. Keith Compton has been appointed Assistant City Engineer of Baltimore, Md. He will have charge of regrading and paving in the burnt district.

Mr. Chas. E. Bright, Assoc. M. Am. Soc. C. E., formerly Resident Engineer Dossitt tunnel L. & N. R. R., is now with the Tidewater R. R. Co., at Roanoke, Va.

Mr. H. E. Wagner has been appointed Division Engineer of the Illinois Division of the Missouri Pacific Ry., with headquarters at Chester, Ill.

Mr. J. J. McVean, M. Am. Soc. C. E., and Mr. H. F. Northrup, M. Am. Soc. C. E., have opened a Consulting Engineering office in the Houseman Bldg., Grand Rapids, Mich.

Mr. George S. Rice, M. Am. Soc. C. E., Acting Chief Engineer of the Rapid Transit Railroad Commissioners of New York City, since last January, has been appointed Chief Engineer.

Mr. W. C. Farrington, formerly with the Consolidated Construction Co., of Philadelphia, is now Engineer and General Manager of the Canadian Construction Co., with headquarters at Toronto, Ont.

Mr. G. A. McCarthy, formerly Engineer of Maintenance of Way and Assistant to the Chief Engineer of the Temiskaming & Northern Ontario Ry., has been appointed Chief Engineer, succeeding Mr. W. B. Russell.

Mr. Olaf Hoff, M. Am. Soc. C. E., who recently resigned as Engineer of Structures of the New York Central & Hudson River R. R., is now Vice-President of the Butler Brothers Construction Co., of 1170 Broadway, New York City.

Mr. John A. Ockerson, M. Am. Soc. C. E., of St. Louis, Mo., has been appointed by the United States Department of State, a delegate to the tenth international congress of International Marine Navigation, to be held at Milan, Italy, September 24 and 25.

Mr. William Carroll, for many years Superintendent of Construction in the Chicago Fire Department, has been appointed City Electrician, to succeed Mr. E. B. Ellicott, who has been made Chief Hydraulic and Electric Engineer of the Sanitary District.

Mr. Charles E. Rogers, at present Professor of Civil Engineering in the Clarkson Memorial Polytechnic School, at Potsdam, N. Y., has accepted the Chair of Civil Engineering, at Trinity College, Hartford, Conn. Professor Rogers was graduated from Rensselaer Polytechnic Institute in 1896.

Mr. Earl Stimson, Division Engineer of Maintenance of Way of the Baltimore & Ohio Southwestern R. R., at Washington, Ind., has been appointed Engineer of Maintenance of Way, at Cincinnati, O. He is succeeded at Washington, Ind., by Mr. M. L. Thayer, who has been Assistant Engineer of the Ohio Division.

Mr. Oscar Erlandson, M. Am. Soc. C. E., has resigned as Assistant Engineer of the Department of Bridges, of New York City, where he has been identified for nearly six years with the design and construction of the Blackwell's Island Bridge over the East River, to become Chief Engineer of the O'Rourke Engineering Construction Co., with offices in the Century Building, No. 1 West 34th St., New York City.

Mr. H. J. Slifer, formerly General Superintendent of the Chicago, Rock Island & Pacific R. R., in charge of operation, motive power and maintenance between Chicago and Denver, has become connected with J. G. White & Co., Inc., 43 Exchange Place, New York, as Steam Railway Expert, and in that position will be in responsible charge of matters relating to the company's steam railway undertakings.

Mr. D. D. McBean, contractor, and the designer and builder of the Harlem River tunnel of the New York Subway, has had the Honorary Degree of Doctor of Laws conferred upon him by the Senate of Queen's University, of Kinston, Ontario. The degree was conferred on April 26, 1905, "in recognition of your eminent services as an engineering constructor of great public works, and especially as the author of new methods of subaqueous tunneling."

Mr. W. H. Knowlton, hitherto Principal Assistant Engineer of the West Shore line of the New York Central & Hudson River R. R., has been made Assistant to Vice-President W. J. Wilgus. Mr. J. W. Eber, who has been Division Engineer of Rome, Watertown & Ogdensburg Division, has been appointed Assistant to the Engineer of Maintenance of Way, with office in New York City. Mr. Eber is succeeded as Division Engineer by Mr. W. Kleefield, Jr., formerly Supervisor of Bridges, on the Mohawk Division.

Rear Admiral Colby M. Chester has informed the Navy Department that the following officers and civilians will accompany him this summer to Spain to view the total eclipse of the sun: Capt. J. A. Norris, Lieut. E. E. Hayden, Prof. W. S. Eichelberger, Prof. F. B. Littell, Photographer George H. Peters, Computer E. I. Yowell, Computer W. W. Dinwiddie; Prof. F. H. Bigelow, of the United States Weather Bureau; Prof. Stanislav Hauzlik, assistant to Prof. Bigelow; Dr. S. A. Mitchell, Dr. N. E. Gilbert, and Dr. L. E. Jewell and assistant.

Obituary.

William H. Davison, member of the firm of Davison Bros., Architects, of Bath, N. Y., died May 16, at his home in that city, aged 52.

Henry Hawkes, Superintendent of the Brooklyn Bureau of Distribution and Repair of the Water Department of New York City, died of apoplexy, May 16, at his home in Brooklyn. He was 68 years old.

L. M. Mosier, a civil engineer in the employ of the Illinois Central Ry., engaged on the extension from Ziegler to Herrin, Ill., was drowned near Duquoin, Ill., while attempting to cross a creek in a wagon.

Philip T. Cronin, Commissioner of Public Buildings, for the Borough of Queens, New York City, died May 16, in St. Mary's Hospital, Jamaica, L. I., shortly after an operation for appendicitis. He was 48 years old.

Le Droict Langdon Barber, President of the Ardsley Electric Co., and the Ardsley Water Co., of Ardsley, N. Y., died May 19, at West End, N. J., aged 32. He was the son of Amzi L. Barber, Chairman of the Board of Directors of the Barber Asphalt Co.

Edwin McCalla Davis, formerly Secretary of the Niles-Bement Pont Co., of New York, died May 17, after an illness, of 18 months, from nervous prostration. He was born in Philadelphia in 1861, and after a course in a Philadelphia technical institute became a mechanical engineer. Soon after leaving College he entered the employ of the Niles Bement Pond Co.

Julius Baier, M. Am. Soc. C. E., General Manager of the Conrey Placer Mining Co., died May 8, at Ruby, Mont. Mr. Baier was a graduate of Washington University and had been identified with many important engineering works in St. Louis, Mo., notably the reconstruction of Eads Bridge, the St. Louis Merchants' Bridge Elevated Railway, and the St. Louis Colosseum.

Henry W. Millar, President of the Charles Millar & Son Co., of Utica, N. Y., whose death was briefly mentioned in our issue of last week, was born in Utica, N. Y., in 1845. At the age of 16 he entered the employ of his father, Charles Millar, and five years later he became a partner in the firm of Charles Millar & Son. The concern was engaged in the manufacture of butter and cheese-making apparatus and subsequently became dealers in plumbers' supplies, iron and lead pipe, hardware, etc. The Utica Pipe Foundry Co. was organized in 1889, Charles Millar being President, and Henry W. Millar Vice-President. On the death of his father the son became President of the company. Mr. Millar was one of the charter members of the Utica Chamber of Commerce, and was largely interested in many business enterprises in addition to those mentioned above.

John Wesley Anderson, M. Am. Inst. Min. E., Vice-President and General Manager of the Carbon Steel Co., died May 19, in the Hospital at Harrisburg, Pa., from injuries sustained in the train wreck May 11, at Harrisburg. Mr. Anderson; his son, Frank W. Anderson; Victor L. Crabbe, Purchasing Agent of the Carbon Steel Co.; Paul Bright, an engineer for the company, and George Loeffler, the chemist, were returning from New York, where they had gone on business connected with a law suit. All the members of the party with the exception of Mr. Bright were either killed in the accident or have since died from injuries sustained in it. Mr. Anderson was also Vice-President of the Union Steel Casting Co., and was the patentee of a number of valuable steel making processes. He was a member of the American Institute of Mining Engineers, of the International Society of Testing Materials, of the Engineers' Society of Western Pennsylvania, of the Railway Club of Chicago, and the Railway Club of St. Louis.

ENGINEERING SOCIETIES.

COMING MEETINGS.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS.
June 6, 7, 8, 9, 1905. Annual spring convention, at Scranton, Pa. Secy., F. R. Hutton, 12 West 31st St., New York, N. Y.

AMERICAN FOUNDRYMEN'S ASSOCIATION.
June 6 to 9, 1905. Annual convention in New York. Secy., Richard Moldenke, Watchung, N. J.

MASTER CAR BUILDERS' ASSOCIATION.
AMERICAN RAILWAY MASTER MECHANICS' ASSOCIATION.
June 14-21, 1905. Annual meeting at Manhattan Beach, N. Y. Secy., J. W. Taylor, The Rookery, Chicago, Ill.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.
June 19 to 23, 1905. Annual convention at Asheville, N. C. Secy., R. W. Pope, 95 Liberty St., New York, N. Y.

AMERICAN SOCIETY OF CIVIL ENGINEERS.
June 20 to 23. Annual convention at Cleveland, Ohio. Secy., Charles Warren Hunt, 220 West 57th St., New York, N. Y.

ASSOCIATION OF TRANSPORTATION AND CAR ACCOUNTING OFFICERS.
June 20, 21, 1905. Annual meeting at Toronto, Ont. Secy., G. P. Conard, New York, N. Y.

PACIFIC COAST ENGINEERING CONGRESS.
June 29 to July 1. At Portland, Oregon. Otto von Geldern, San Francisco, Cal., or Milnor Roberts, Seattle, Wash.

PACIFIC NORTHWEST SOCIETY OF ENGINEERS.
June 29 to July 1. Annual convention at Portland, Oregon. Secy., Milnor Roberts, Seattle, Wash.

LEAGUE OF AMERICAN MUNICIPALITIES.
August 23 to 25. Annual meeting at Toledo, O. Secy., J. McVicar, Des Moines, Ia.

AMERICAN SOCIETY OF MUNICIPAL IMPROVEMENTS.
Sept. 5 to 7. Annual meeting at Montreal, Canada. Secy., Geo. W. Tillson, Brooklyn, N. Y.

ROADMASTERS & MAINTENANCE OF WAY ASSOCIATION.
Sept. 12, 14. Annual meeting, at Niagara Falls, N. Y. Secy., C. E. Jones, C., B. & Q. Ry., Beardstown, Ill.

ASSOCIATION OF TRANSPORTATION AND CAR ACCOUNTING OFFICERS.—The second annual meeting of the association will be held at the King Edward Hotel, Toronto, Ont., on June 20 and 21, 1905. All railway officials interested in transportation, car service, or car accounting are invited to attend. A session will be held at 11 a. m. of each day. The committees on Per Diem, on Car Service, and on Office Methods and Accounting will present reports. Secy., G. P. Conard, 24 Park Place, New York, N. Y.

AMERICAN FOUNDRYMEN'S ASSOCIATION.—The eighth annual meeting of this association will be held at New York city on June 6 to 9, 1905. Headquarters will be at the Murray Hill Hotel, a block from the Grand Central Station. Reduced fare, on the certificate plan, has been granted by the Trunk Line Association, and to secure this, a one-way ticket, with certificate, should be purchased between June 2 and June 7, and delivered to the Secretary before noon, June 7. The program of the meeting contains a large list of papers. Sessions will be held only during the daytime, so that the evenings will be free for sightseeing. One entire day will be spent at Columbia University. Secy., R. Moldenke, Watchung, N. J.

SOUTHERN ALLEGHANY ENGINEERING SOCIETY.—On January 26, 1905, note was made in this column of a movement to form an engineers' society in West Virginia and the surrounding territory. Mr. H. M. Payne, who initiated the movement, now writes us that a meeting for purposes of organization will be held on Saturday, June 10, 3 p. m. (Eastern time) at his office in the city

of Williamson, W. Va. Interest in the movement has developed in a wide territory, including North Carolina, Tennessee, Kentucky, parts of Virginia, and West Virginia. As most of the states named have no engineering society, there should be a very promising future before the proposed organization. All persons interested in the movement are invited to attend the meeting at Mr. Payne's office or send their views in writing.

AMERICAN SOCIETY OF REFRIGERATING ENGINES.—This society, organized at a meeting held in New York City on Dec. 5, 1904, has issued its first year book, a pocket list of membership, containing also the constitution, by laws, list of officers, etc. The society holds annual meetings in December, and "such other meetings held at such time and place as the council may appoint." Its present officers are: President, Mr. J. E. Starr, of New York City; Vice Presidents, Messrs. H. B. Roelker, of New York City and P. D. C. Ball, of St. Louis, Mo.; Managers, Messrs. L. Block, W. E. Parsons, E. L. Phillips, H. Torrance, Jr., and L. H. Jenks, of New Yory, N. Y., E. Penney, of Newburgh, N. Y., D. S. Jacobus, of Hoboken, N. J., W. T. Robinson, of Philadelphia, Pa., and T. Shipley, of York, Pa.; Secretary, Mr. W. H. Ross, of New York, N. Y.; Treasurer, Mr. W. C. Reid, of New York, N. Y.

GENERAL ASSOCIATION OF MUNICIPAL SANITARIANS (France).—A new technical society to cultivate the field of municipal sanitation has been formed in France within the past few weeks. The organization bears the name "Association Generale des Ingenieurs et Hygienistes Municipaux" and is designed to unite the sanitarians of the French speaking countries, France, Belgium, Switzerland, Luxembourg and Algeria. The promoters of the association are: Dr. Ed. Imbeaux, Director of Public Works, Nancy, France; Mr. V. van Lint, Engineer of Water-Works, Brussels, Belgium; Mr. H. Peter, Engineer of Water-Works, Zurich, Switzerland; and Mr. L. Klein, Chief of the Bureau of Agriculture, Luxembourg. The association is intended to embrace primarily engineers connected with cities and towns in water-works, sewerage, or highway service, in the countries mentioned, but men interested in the same work in other countries will be received as corresponding members. The association will publish a yearly journal, whose cost is embraced in the annual dues of 20f. ($4). For further information Dr. Imbeaux of Nancy may be addressed, or a prospectus of the association may be obtained from the office of Engineering News.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS.—As already noted the spring meeting of the society will be held at Scranton, Pa., with headquarters at the Hotel Jermyn. The first session is scheduled for 8.30 p. m. of Tuesday, June 6, the second and third for Wednesday morning and evening and the last for Thursday morning. All four sessions will take place in the auditorium of the Y. M. C. A. building, three blocks from the headquarters hotel. The program of professional papers follows: "The Transfer of Heat at High Temperatures," by F. C. Wagner; "A Standard Unit of Refrigeration," by F. E. Matthews; "The Formation of Anchor Ice and Precise Temperature Measurement," by Prof. H. T. Barnes; "Some Types of Centrifugal Pumps," by W. O. Webber; "Microstructure and Frictional Characteristics of Bearing-Metals," by Melvin Price: "Cast-Iron, Crushing Loads and Microstructure," by W. J. Keep; "Smoke and its Abatement," by C. A. Benjamin; "Can a Steam Turbine Be Started in an Emergency Quicker Than a Reciprocating Engine of the Same Power," by A. S. Mann; "Note on the Efficiency of Steam Generating Apparatus," by A. Bement: "Performance of a Superheater," by A. Bement; "Counterweights for Large Engines," by Prof. D. S. Jacobus; "Steam-Actuated Valve Gear," by W. H. Collier; "Note on Heads of Machine-Screws," by H. G. Reist; "Belt Creep," by W. W. Bird; "The Function of Laboratory Courses in the Curriculum of Engineering Schools," by Prof. C. E. Lucke; "Continuous Measuring and Mixing Machines," by E. N. Trump; "Epochs in Marine Engineering," by G. W. Melville.

PACIFIC COAST ENGINEERING CONGRESS.—Supplementing the note given of the Pacific Coast Engineering Congress in our last issue, we present here a preliminary outline of the program, as communicated by Mr. Otto von Geldern, secretary of the Technical Society of the Pacific Coast, one of the organizing bodies of the Congress. The program covers the five days, June 29 to July 3, 1905. At the opening session, 10 to 12 a. m., of Thursday, June 29, an opening address will be delivered, followed by a general recention. Professional sessions follow at 2 p. m. Thursday, 10 a. m. Friday June 30, and 2 p. m. Friday. Saturday, July 1, will be used for a steamer trip up the Columbia River to Cascade Locks and Celilo Canal, and Sunday for a trip down the river to the jetty work at Astoria. On Monday, July 3, an excursion by special train will be made to Oregon City and Cazadero, to see the water-power plants of the Portland General Electric Co. and the Oregon Water Power & Railway Co., now under construction.

The following papers have been announced up to the present time: "Reinforced Concrete Construction," by L. A. Hicks, and a paper describing a 300-ft. chimney stack of reinforced concrete; "Pacific Coast Industrial Engineering Problems," by Geo. W. Dickie; "Timber Tests, their Methods and Results," by L. E. Hunt; "The Principles Governing the Valuation of Water-Works under Private Ownership," by A. L. Adams; "The Struggle for Water in the Great Cities of the United States," by M. Manson; "Reclamation of Tidal Areas," by O. von Geldern; "Control of Hydraulic Mining Debris in California by the Federal Government," by Capt. Wm. W. Harts; and papers on "The Cazadero Plant," "Government Improvements at the Cascades of the Columbia River," "Improvements at the Mouth of the Columbia by the United States Engineers," and on several irrigation subjects.

BROOKLYN ENGINEERS' CLUB.—At the regular meeting of Thursday, May 11, held at the club rooms, 197 Montague St., Brooklyn, N. Y. Mr. J. C. Meem gave an illustrated address on "Some Recent Methods of Tunneling in Soft Ground." The address treated particularly of soft-ground work other than subaqueous and pneumatic, although shield tunneling and subaqueous work were touched to some extent. In general, the methods described were grouped in several classes: the crown-bar method, the pilot-tube method, combinations of the two, and methods using partial shields. The method of sectional roof shields, or modified poling boards, as developed in Brooklyn sewer tunnel work, comes under the last head, as does also the roof-shield method, as most successfully used in the Boston street-car subways. The full shield method is not included in the above grouping, as its principles are quite distinct from those of partial-shield work. The crown-bar method, which is the simplest tunneling method, the poling-board method applied to large tunnels by means of longitudinal crown-bars supported on timbering and carrying transverse poling boards, has many faults which make it inferior, among them its cost, slow progress, loss of timber left behind the lining, and principally the unavoidable and great settlement involved, both initial settlement and that produced later by rotting of the abandoned timbers. It has been very widely used, however, and more workmen trained in it can be found than for any other emthod. The pilot-tube method avoids most of the settlement involved in the crown-bar method, but it is also slow, liable to give trouble through deflection of the pilot-tube, and requires more expensive plant. The sectional roof shield method has proven to be safe, rapid and simple. The unit or shield section for this method consists of two 10-in. I-beams held about 12 ins. apart by diaphragms, carrying a flat roof, 2 to 3 ft. wide, of four to six-inch timbers laid longitudinally on the I-beams and projecting beyond them at either end. The front edge of this roof is beveled to form a cutting edge. The timbers are covered by a continuous ½-in. steel plate, bent down over the cutting edge at the front and projecting out about 24 ins. at the rear to form the tail under which the temporary timber lining or the final masonry lining is built up. Rates of progress up to 220 ft. per month, under favorable conditions, and over 10 ft. per day, have been reached with this method. Secy., Joseph Strachan.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.—The annual meeting was held at Carnegie Hall, 154 West 57th St., New York City, on the evening of Tuesday, May 16, 1905, with President J. W. Lieb in the chair. The annual routine business (presentation of committee reports, election of officers, etc.) was transacted, and two technical papers were read and discussed. The following officers were announced elected: President, Mr. Schuyler Skaats Wheeler, Ampere, N. J.; Vice-Presidents, Mr. Charles A. Terry, of New York City, Mr. Townsend Wolcott, of New York City, and Mr. Gano S. Dunn, of Ampere, N. J.; Managers, Mr. Cummings C. Chesney, of Pittsfield, Mass., Mr. Calvert Townley, of New Haven, Conn., Mr. Bancroft Gherardi, of New York City, and Mr. C. L. Edgar, of Boston, Mass.; Secretary, Mr. R. W. Pope, of New York City; Treasurer, Mr. G. A. Hamilton, of New York City. The two last-named are re-elected.

The secretary's report showed a membership of 3,460 (Honorary 2, Members 482, Associates 2,976), and in addition about 160 Associates elected within the past month. The Finance Committee's report showed total assets of about $90,000, of which about $40,000 is in cash, the rest in property (mainly the library). The past year's receipts and expenditures were about $43,000 and $37,500 respectively, leaving a balance of about $5,500. These receipts do not include building fund, medal fund and some other special receipts. The Union Engineering Building Committee reported that in the past year the United Engineering Society had been incorporated as a special holding corporation for the Union building; it is to consist of and be controlled by nine persons, three members from each of the three founder societies, which nine men will govern the building, apportion space, and assess contributions on the founder and associate societies. Bids will soon be called for on the Union building, and excavation work will begin next week. The contract for the Engineers' Club building, a wholly separate proposition, has already been let. The American Institute of Electrical Engineers committee on Land and Building Fund reported that by hard work a total subscription list of about $66,000 has been realized, an advance of $21,000 during the year.

The recent award of the first John Fritz Medal to Lord Kelvin was announced. The Edison Medal for [illegible]dents has not yet been awarded, and small interest is shown in it; about 120 technical colleges of proper standing have been invited to contest for it but only 5 replies have been received. Nothing new was reported by either the Standardization committee or the National Electric Code committee. The Board of Examiners, which passes upon applications for membership, made some interesting comments on the society's rules and grades of membership. During the year some 500 applications for associate membership were approved; 54 applications for transfer from Associate to Member grade were considered, but only 28 were approved. Many persons appear to believe that the requirements for the Member grade are too stringent, while others believe them too low; the chairman recommends that if anything they should be raised. He also recommends that those Associates who are in line for transfer to Member should by some means be differentiated from the Associates who are less directly connected with electrical engineering practice; and also that a suitable grade of membership be created higher than Associate, for men who are prominent in related fields but not engaged directly in electrical engineering practice. No action was taken on these recommendations, all reports being adopted by a blanket vote.

Following the business of the evening, a paper was read by Mr. G. F. Chellis, of New York, on "Time-Limit Relays," and one by Mr. H. W. Buck, of Niagara Falls, N. Y., on "Duplication of Electric Apparatus to Secure Reliability of Service." The papers were discussed by Messrs. Stott, Torchio, Ricker, Wells, Strong, Hemingway and Mailloux.

The first paper described the principles and characteristics of electric power-current relays. Three different types were mentioned: straight overload relays, which operate when the current exceeds a set value, in either direction; reverse-current relays, which operate at a set value of reversed current only; and differential relays, which operate at lower current value with reversed current than with normal direction of flow. The characteristics of various differential relays were discussed, especially with regard to the resistance and phase relations of their two coils. Differential relays were recommended for protecting alternators, but were declared unsuitable for use on feeders. On the latter, straight overload time-limit relays should be used, according to experience on the Manhattan Elevated lines of the Interborough Rapid Transit Co. in New York. Several other requisites of relay protection of the various parts of a distributing network were also discussed in the paper.

Mr. P. Torchio, in discussion, told of the failure of the early relay installation on the New York Edison Co.'s distributing system, when straight overload relays were used on the generator end of the feeder in combination with reverse-current relays at the receiving end. After full investigation it was found that [illegible]ough and carefully adjusted system of relays with time element had to be used. The dashpot type of relay was not successful, but the bellows type proved to be just what was wanted. At present the time-element relays are set to operate in the following order: (1) that on the d. c. side of the rotaries, (2) that on the a. c. side of the rotaries, (3) that on the high-tension feeder at the substation, and (4) that on the feeder at the generating station. They are so arranged that, when one relay opens, all the others must reset and clear themselves. It is found, however, than on a heavy short in a feeder the relays at both ends open practically simultaneously.

The second paper gave a broad discussion of the principles which should govern the amount of duplication in an electric system and the amount and distribution of reserve apparatus. Special stress was laid on the "storeroom reserve" of parts of machinery, cables, supplies, etc. The author also expressed the opinion that, in the operation of important railway lines by electricity, supply by a single generating station will prove too unreliable, and that two or more stations of moderate size will give better reserve protection. Mr. H. G. Stott differed from this view, holding that no limit is in sight for size of generating stations and that the modern subdivision of stations into a number of separate parts throughout gives greater reliability than is obtained from two independent stations. However, in railway work the interruptions due to electrical troubles are but a small part of the total interruptions of service, less than 1% in a large system during three years past. On this account the need for duplication should not be considered to be so great. A limiting condition to-day, where underground distribution must be used, is the possible voltage on cables, and this affects the necessary duplication of cable plant. Low voltage (and hence heavy current) increases the danger of serious burnout when a short occurs. It is expected that within a few years cables will be used at 25,000 volts, and that they will be less of a source of serious interruptions than cables are at present.

On the subject of relays, Mr. C. W. Ricker asserted that this is not a purely electrical question, but that the generating end requires consideration. In one plant, with the relays set to work even in the shortest possible time, the engines slowed badly every time a short occurred, which trouble would of course have been more serious if relays with longer time constant had been employed.